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The ADVANCEMENT OF SCIENCE

Vol. IV, No. 14

Charles Darwin's Life at Downe

London Traffic and the London Plan

The Numbers and Distribution of Mankind

Published by the

BRITISH ASSOCIATION
for the Advancement of Science

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NOTES

PRESIDENTS OF THE ASSOCIATION

THE Association mourns the loss, in May, of two past Presidents, Sir Thomas Holland, K.C.S.I., K.C.I.E., F.R.S., who was President in 1929 (South Africa) and an active permanent member of Council thereafter, and Sir Frederick Gowland Hopkins, O.M., F.R.S., who was President in 1933 (Leicester).

On January 3, on the occasion of the installation of Sir Henry Dale as President for 1947, a message of congratulation was sent to Field-Marshal Smuts (President, 1931) on the award of the Order of Merit. The following is an extract from a letter received later from Field-Marshal Smuts :—

'I am proud to think that I was once President of the greatest Science Association in the world, although myself innocent of all scientific pretensions. But science has such a rôle and such a message for our age that even such as I cannot but look upon it as one of the main factors in shaping the new world—perhaps even the most important factor of all. The Association is involved in the vast transition through which the whole world is moving and its outlook must also be correspondingly affected and changed. I hope your second century will be even more distinguished and memorable than your brilliant first. Science has come to us as the greatest revelation of the modern age.'

ANNUAL MEETING AT DUNDEE

PREPARATIONS are well in hand for the first full post-war meeting of the Association, which will be held in Dundee from August 27 to September 3, and every endeavour is

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being made by all concerned with the arrangements to ensure that this meeting, no less than all that went before it, will be one of the most important scientific events of the year.

The Preliminary Programme, which was published early in May, has been sent to many thousands of subscribers and supporters. Copies are still available and will be sent on application to any others who are interested.

There is every indication of a renewal of the local interest and enthusiasm which marked previous meetings held in Dundee in 1867, 1912 and 1939, and a large local membership is expected. Registrations of visiting members and associates have, at the time of writing, been received at a much higher rate than was normal before the war, and accommodation is being rapidly reserved. It will assist the local Hospitality Committee in making their arrangements, if those who wish to attend will give early indication of their requirements.

Of the city itself, which has a commanding situation on the north bank of the Tay, the following description is given in the Preliminary Programme :

It is probable that many visitors to Dundee think of it mainly as an industrial centre, occupied with the manufacture of jute and marmalade : but it is actually a burgh, which, during a long and varied, if chequered, history, has played its part faithfully, and has never lacked either courage or adventure in its commercial enterprises. It was in Dundee that a National Council of Clergy ackowledged the right of Robert Bruce to the throne in 1309 : it was into the harbour of Dundee that Sir Andrew Wood of Largo triumphantly towed the ships of Stephen Bull after the naval victory over the English in 1490 : the burgh was one of the chief storm centres at the time of the Reformation in the middle of the sixteenth century : it suffered siege and sack by the Cromwellian troopers under General Monck in 1651 : the Old Pretender spent a night here in 1715, and sixty years later Dr. Johnson passed through the town, of which Boswell remembered ' nothing remarkable.'

For long Dundee was the centre of the linen trade in Scotland, and at the time of the Union of the Parliaments in 1707, it is said that over a million and a half yards of linen were made annually, but this can only be an estimate. Flax was grown in Scotland in those days, and it must have been a pleasant sight to see the fields on the Fife shore of the Tay, from Newport to Tayport, gay with blue-tinted flowers. The manufacture of jute had tentative beginnings early in the nineteenth century, but with the cotton famine, caused by the American Civil War, the demand for jute goods increased enormously. The imports of raw jute in 1863 were 46,983 tons : ten years afterwards they were treble that amount.

Shipbuilding was for long a flourishing industry, and in the making of wooden vessels the port held is own. The ' Forfarshire,' associated with the name of Grace Darling, came from a Dundee shipyard, and so did Captain Scott's ' Discovery.' The whaling industry was another enterprise of last century, and the older generation remember with a thrill the excitement over the departure of the ' Balaena,' the ' Active,' the ' Terra Nova,' and other whalers for the unknown North, and the equally exciting days when they returned with their catches.

Besides textiles, engineering in many branches, shipbuilding in its later developments, and other industries play a prominent part to-day in the life of the city.

On the opening day of the meeting, at noon, the freedom of the City will be conferred on the President, Sir Henry Dale, who will be the first President to receive such an honour on the occasion of an annual meeting. In the evening he will deliver his Presidential Address on ' Science in War and Peace ' which is the theme of the meeting as a whole.

On the following morning the thirteen sections open their proceedings which will cover a wide variety of topics under the general heading of ' Swords into Ploughshares ' which reflects the desire of the Council of the Association that this opportunity should be taken of reviewing the positive contributions which science has made and can make to human progress. At the request of the Council the Sections, in drafting their programmes, have taken into account the desirability of arranging papers and discussions which will be readily intelligible to non-specialists, but as meetings of the Association serve a number of useful purposes, the programme will also include some specialist papers, and communications by young scientists on specialist subjects.

Outlines of the sectional arrangements are given in the Preliminary Programme together with announcements of excursions, visits to works, evening lectures and entertainments. The B.B.C. are planning a daily series of direct broadcasts and reports by observers, during the week of the meeting.

It is contemplated that one number of *The Advancement of Science* will be entirely devoted to the texts of the Presidential Address and the sectional Presidential Addresses. Subsequent numbers will contain a descriptive record of the week's proceedings and full reports on selected items.

The following are the titles of the Presidential Addresses to the Sections :—

Sir Edward Appleton, G.B.E., K.C.B., F.R.S., on ' Earth, stars and radio.'

Dr. J. L. Simonsen, F.R.S, on ' Science and the colonies.'

Dr. M. Macgregor, on ' Geology in the development of the coalfields.'

Dr. Edward Hindle, F.R.S., on ' Zoologists in war and peace.'

Prof. Eva G. R. Taylor, on ' The Geographer in war and peace.'

Sir Wm. Halcrow, on ' Progress in modern engineering.'

Prof. C. Daryll Forde, on ' The anthropological approach in social science.'

Prof. Winifred Cullis, C.B.E., on ' Physiology and the community.'

Dr. S. J. F. Philpott, on ' Man's adaptability.'

Dr. H. Hamshaw Thomas, on The history of plant form.'

Miss Lynda Grier, on ' The evolution of secondary education in England.'

Dr. W. G. Ogg, on ' Soils and health.'

American Association for the Advancement of Science

The Association was represented at the Christmas meeting of the American Association at Boston by Prof. C. B. Fawcett, Prof. J. B. S. Haldane and Prof. D. M. S. Watson. At this meeting Prof. Fawcett gave the first of the British-American Association lectures since the war, his subject being ' The Numbers and Distribution of Mankind.' The lecture is printed here by arrangement with the American Association.

Dr. Kirtley F. Mather, a member of the Executive of the American Association, has accepted an invitation to deliver the exchange lecture in Dundee.

Indian Science Congress Association

The Association collaborated with the Royal Society and the British Council in sending a delegation to the annual meeting of the Indian Science Congress Association at Delhi in January. The British delegation consisted of Prof. P. M. S. Blackett, F.R.S., Prof. Wm. Brown, F.R.S., Sir Charles Darwin, K.B.E., F.R.S., Sir Arthur Fleming, Prof. H. Munro Fox, F.R.S., Sir Harold Spencer Jones, F.R.S., Prof. L. J. Mordell, F.R.S., Prof. L. Dudley Stamp, and Sir D'Arcy W. Thompson, C.B., F.R.S. Delegations were also sent from Canada, France, Russia and U.S.A.

Sir Charles Darwin presented to Pandit Nehru, President of the I.S.C.A., the following message from the President and Council of the British Association :—

' On behalf of the British Association we greet with a special welcome the initiative taken by your Association in inviting men of Science from other countries to be present at your meeting at Delhi and to take part in its proceedings. We value most highly the opportunity thus given to men of Science from Britain, among those from many lands, to acquaint themselves more directly with the great achievements, past and present, and the prospect of yet greater developments of India's contribution to the advancement of Science and of its applications to the progress of civilisation and the enlargement of the means of human happiness. The present time is one of heavy commitments and pressure of duties for many of our British men of Science ; I myself share with others a profound regret at our inability to accept your invitation for ourselves. We are glad indeed that it has been possible, nevertheless, for an important delegation of our colleagues to accept the invitation which you extended through the British Association, to bring you these greetings and to be present in person at your meeting.

' You may be assured that we, with all the Members of the British Association, fully and gratefully recognise the service rendered, by the generous enterprise of the Indian Science Congress Association, to that rebuilding of a truly international community in Science, on which the future of human civilisation has such a manifest and growing dependence. It is our earnest hope that the bonds of friendship and collaboration already uniting your Association and ours may thereby be strengthened, that they may find a wide extension to the cognate organisations of all countries, and that opportunities for such international meeting and interchange of scientific experience may become ever more frequent and inclusive.

' We have noted with interest your intention to give prominence, in the meeting of your Association at Delhi, to discussion of the place of scientific research in national planning. We hope, indeed, that such discussion will be found to give strength and direction to the promotion in India of research in the fundamental sciences and their practical applications, as an essential factor of a constructive effort to solve India's social and economic problems, and therewith to aid the solution of those with which the devastation of war has burdened so large a part of the world.'

Howarth Portrait Fund

It has been decided that Dr. O. J. R. Howarth, who retired in 1946 after being Secretary of the Association for 37 years, will be presented with his portrait in oils by

Robin Darwin, Professor of Fine Art at Newcastle. The portrait will be handed to Dr. Howarth at the Dundee Meeting. A large number of members have subscribed to a Portrait Fund and the Treasurer will gladly acknowledge further subscriptions from any who may not have received notice of the Fund.

Down House

This issue contains an article on the Life of Charles Darwin at Down House, Downe. Darwin's home in Kent, from his thirty-fourth year, where he thought and worked for forty years, is maintained by the Association as a national memorial, and was re-opened to the public in 1945 after being closed owing to war years. The proper maintenance of the estate, the house, and its contents, which include much of Darwin's furniture, books, equipment and other possessions, is an honourable charge of the Association. Unfortunately, however, the rise in cost of upkeep together with falling income from investment of the money with which the property was endowed, leaves a gap of the order of £800 a year which the Association must find, with some difficulty, from general funds. To fill this gap is one of the urgent tasks with which the Officers and Council of the Association are at present faced.

Memorial Lectures

The Association maintains three memorial lectures all of which fell due to be delivered this year. The Norman Lockyer Lecture was delivered in the Caird Hall, Dundee, on April 10 by Sir Robert Watson Watt, F.R.S., who spoke on 'Radar in War and Peace.' The Radford Mather Lecture was given to members of the University of Cambridge in the Arts School on May 2 when Sir Howard Florey, F.R.S., spoke on 'Penicillin and other Antibiotics.' Professor E. D. Adrian, O.M., F.R.S., gave the Alexander Pedler Lecture to a public audience in the Royal Institution, Albemarle St., London, on the 'Subject of the Sense of Smell.' It is hoped to print all three lectures in full in a forthcoming number of *The Advancement of Science*.

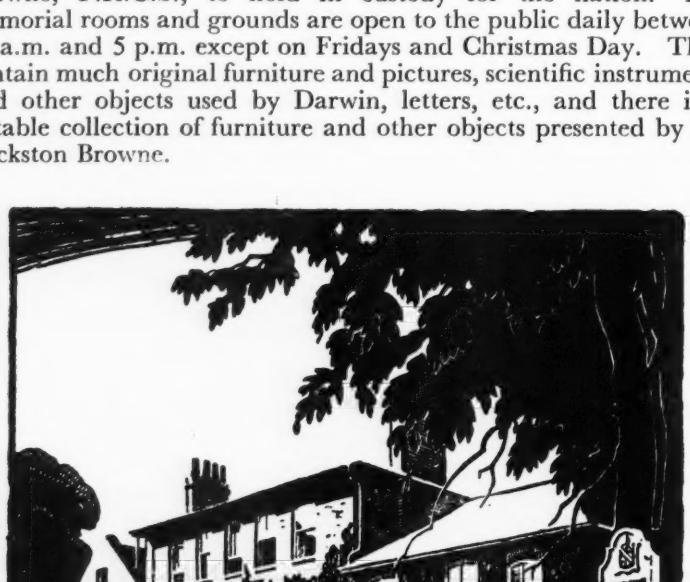
The Place of Universities in the Community

At Manchester University, which is recognised in academic circles as an active centre of University reform, the Division for Social and International Relations of Science held a one-day conference on May 10 on 'The Place of the Universities in the Community.' The conference which was held in two sessions, over which Lord Simon of Wythenshawe and Sir Henry Dale presided, was well attended by representatives from Universities, Technical Colleges, Schools, industry, learned societies and institutions. The agenda for the conference included perhaps too many topics for a one-day meeting, but the conference provided an opportunity for ventilating a number of the more important problems with which Universities are faced at present and editorial comment in newspapers and periodicals recognised the conference as a commendable service in the public interest. The Conference passed two resolutions asking the Council of the Association, first, to request the University Grants Committee, in collaboration with the Universities, to ascertain and publish data on the careers of University graduates and, secondly, to urge the Universities of the British Empire not to accept research contracts which included restriction and freedom of publication. These resolutions will be considered by the Council in due course.

As a further contribution to the study of the problems facing those responsible for educating the citizens of to-morrow the Association is arranging a discussion at Dundee on 'The Education of the Man of Science,' when it is planned to consider the matter from the point of view of the schoolmaster, the university professor, the university administrator, and the industrialist. It is hoped that some large measure of agreement may be reached on the nature and content of the teaching which should be given in schools and in universities as a preparation for the professions, and that it may be possible to determine where the responsibility lies for any undue degree of specialisation at either stage.

DOWN HOUSE

DOWN HOUSE, Downe, Kent, the home of Darwin from 1842 to 1882, was presented to the Association by the late Sir Buckston Browne, F.R.C.S., to hold in custody for the nation. The memorial rooms and grounds are open to the public daily between 11 a.m. and 5 p.m. except on Fridays and Christmas Day. They contain much original furniture and pictures, scientific instruments and other objects used by Darwin, letters, etc., and there is a notable collection of furniture and other objects presented by Sir Buckston Browne.



Catalogue of the collections, price 6*d.* ; postage 2½*d.*

A History of Darwin's Parish : Downe, Kent, by Dr. O. J. R. HOWARTH, Curator of Down House, and Mrs. HOWARTH, with a Foreword by Sir ARTHUR KEITH, F.R.S. Published by RUSSELL & CO. (SOUTHERN COUNTIES), LTD., Southampton : to be obtained of all booksellers, or from Down House. Price, 1*s.* 6*d.* ; postage 3*d.*

(Railway station, Orpington, S.R. 4 miles : cars on hire, adjacent. Omnibus service 146 Bromley-Downe via Keston. Distance by road from London Bridge, 16 miles. Postal address, Down House, Downe, Kent. Telephone, Farnborough, Kent, 6.)

CHARLES DARWIN'S LIFE AT DOWNE [1]

By Dr. O. J. R. Howarth

It is common knowledge that Charles Darwin's home at Downe, in Kent, is preserved as a memorial—one of the very few examples in the world of the memory of a great scientist so honoured. When Sir Arthur Keith, as President of the British Association in 1927, concluded his address on Darwinism, as it then stood, with a plea for the preservation of Down House, that plea was immediately answered by a well-known surgeon, and a profound admirer of Darwin, the late Sir Buckston Browne, who bought the house, restored it, and gave it into the custody of the Association with an endowment towards its upkeep. The memorial rooms were opened to the public in 1929, and the number of visitors before the war was maintaining an average of some 7,000 each year, so that the establishment of this shrine of pilgrimage to the memory of one who brought about a revolution in civilised thought has been justified by the appreciation which the public has shown.

The outline of Darwin's life is simple and well known. His father, Robert Waring Darwin, of Shrewsbury, and his grandfather, Erasmus Darwin, were successful medical men. He himself, educated at Shrewsbury, owed nothing to the formal classical school teaching of his time, and little to the actual teaching which he received at the universities to which he proceeded—first Edinburgh, where he discovered his distaste for a career in medicine, and then Cambridge. But the power of observation, the interest in collecting such things as beetles, and even in a measure of experiment, innate in him and revealed in childhood, were developed at Edinburgh and still more at Cambridge through contacts with men skilled in natural sciences who recognised the boy's true bent and responded to that extraordinary charm of personality which remained with him throughout his life.

It was to this friendly and informal recognition of his talent, and not to any high academic achievement, that Darwin owed his selection as naturalist to accompany H.M.S. *Beagle* on her surveying voyage round the world. This is not an occasion to discuss the details of the voyage, which Darwin afterwards regarded as the outstanding event of his scientific career : certainly it is clear from the notebooks and diary which he kept on the voyage, and which are now among the priceless possessions of the British Association, that the observations and experiences of these years of travel included the foundation-stones of the thought and work which brought him fame. It was the first of his great achievements that he made for himself, during the voyage, a place as a leader among scientists, for as such he was soon recognised after his return home in 1836. During the next six years he married his cousin, Emma Wedgwood, and they set up house in London. This was in Gower Street, a structure of stolid comfort but meritless appearance, which now has vanished owing to enemy action in 1940. But during the period of his residence there, Darwin fell into the unreliable state of health from which he suffered more or less for the rest of his life. Neither he nor his wife was suited by life in London ; they cast about for a retired country home from which London should be not too difficult of access, and after much search they found it in Down House.

We know something of the history of this property back to 1651. It came into the hands of a wealthy man of business, Butler by name, in 1778, and the style of the main part of the house accords with its having been built about that time, certainly on the site of an earlier house. As Darwin found it, it was a large square house of three storeys, with an annexe containing kitchen premises and servants' quarters. Its material, except for some flintwork, probably of the earlier house, is of what seems to have been a not unpleasing brick ; and present taste may with some reason regret the record in the *Life and Letters* that ' The house was made neater by being covered with stucco,' a stuff, moreover, which makes not infrequent demands upon the services of the painter. Darwin's additions to the house modified its severe outlines. In the earlier part of his occupation he added the bay which pleasantly breaks the garden front, and towards the end of his life, as his family grew up, he built a north wing of only two storeys, containing a new dining-room and verandah, a new study for himself, and bedrooms above. The house thus came to contain two dozen rooms, mostly of good size, exclusive of kitchen accommodation. Five of the ground-floor rooms are now open to the public. Of these, the old study, where all Darwin's greatest work was done, is furnished as he had it, with his own furniture and books. The drawing-room just mentioned contains also much that was his, and apart from the associations with him presents a not unwelcome Victorian picture. (The

[1] Expansion of a note for the Alexander Pedler Lecture of the British Association, given at the meeting of the South-Eastern Union of Scientific Societies, July 11, 1946.

appearance of the rooms in Darwin's day is known from contemporary photographs and drawings.) The new study is now a repository of Darwiniana, furnished as a museum, not a living-room. Of the other rooms, one contains many relics of the British Association, as well as some of Darwin ; another, much fine furniture and objects of art from the late Sir Buckston Browne's collection, appropriate in a measure to the times of Erasmus Darwin and Josiah Wedgwood, especially the pictures by Joseph Wright and George Stubbs, who were associates of theirs. Down House is distant nearly half a mile from Downe village (spelt Down in Darwin's time) which is 16 miles distant from London Bridge, and in Darwin's early days was 8½ miles from the nearest railway station : the corresponding figure even now is four. Downe has emerged safely from a threatening period when, not many years ago, a railway was planned to run quite near it, and suburbanisation would inevitably have followed. That project lapsed, and a little later an opportunity was taken to acquire for London's Green Belt, the beautiful High Elms property which earlier belonged to John Lubbock, first Lord Avebury, that versatile scientist, antiquary, statesman, and man of affairs with whom Darwin, soon after his coming to Down, established an intimate friendship which lasted for their joint lives. If Down House is Darwin's visible memorial, so should the High Elms estate, which beautifies the neighbourhood of Downe be viewed as a memorial of Avebury, another great figure of their period.

Darwin's father bought Down House for him, and there he came from London with his wife and two eldest children in 1842 ; there he lived until his death in 1882, and there all his greatest works were written. We can see to-day the room in which he did this, the chair in which he sat, the knee pad on which he wrote, the books, pictures and other furnishings which were his. His early days at Down were spent largely in getting the place into order ; it had been unoccupied, and there was much to be done not only in the house, but in the garden. We learn, for example, that he caused the lane which leads to the house—a German visitor in later years called it a mule-track—to be lowered, and used the soil to make the mounds which still stand about the lawn. In this work he was helped by his elder brother, Erasmus Alvey Darwin, a Londoner by inclination, who at first christened Charles' new home ' Down-in-the-Mouth,' but was converted later to its charm. The property at that time covered 18 acres ; it was subsequently increased to its present figure of 23 acres by the acquisition of land for an orchard and other purposes, and by the purchase of the famous Sandwalk, the bit of woodland where in the years to come Darwin took his almost daily exercise.

The home was established as that of a comfortable country family : it may be said here that Darwin's father was in a position to provide for him amply ; and Darwin himself became in the course of year a man of great wealth, thanks largely to his own very business-like conduct of his affairs. There is a letter to him dealing with these, from one of his sons, written in 1881, which asks, in a postscript : ' Did you ever expect to be worth over a ¼ of a million ? ' In spite of the most generous provision for the needs of his large family, he lived always within his income at Down. In this connection, we have among his papers a note of the receipts from his published works, down to the end of the year 1881, within a few months of his death. The total sum is £10,248—such was the monetary reward for (among other matters) revolutionising human thought. This note, by the way, is one of certain documents which suggest as it were a business-like appreciation of the approach to his life's end.

It is not the purpose here to discuss his work, but rather the setting in which it was done. The home life at Down House is particularly well documented, in the *Life and Letters of Charles Darwin*, compiled by his son, Francis, in *Emma Darwin, a Century of Family Letters*, collected by his daughter, Mrs. Litchfield, and in the account-books and other personal papers faithfully preserved and now in the keeping of the British Association. The reason for this careful documentation and treasuring of records is without doubt to be found in the powerful bonds which knitted the family to their parents, to each other, and to their home. Darwin observed and recorded details about his home, in consonance with his love of observation and record. Thus : the house was of course, in those days, supplied with water from a well. We have his notes on its depth of 325 feet in 1843, with a depth of water of 65 feet. Nine years later the sounding to the bottom was 328 feet, and the water 42 feet deep. There are calculations of the weight of the chain and buckets, and of the time taken in winding. There is a list of weeds which grew on his lawn, and such records—trivial, they may seem, but in one case at least they led to results of scientific value. For his last published work, *The Formation of Vegetable Mould through the Action of Worms*, was based upon observations on his own ground, begun not long after he settled at Down, and carried on with that patience which was ever one of his outstanding scientific characteristics. Among his meticulously kept accounts, which are an index of some interest to the expenses of running such an establishment as Down House in those days,

we note that for the supply of the house, cows and pigs were kept, in addition to horses for the carriage, as well as for himself to ride. He had been an ardent and fearless rider in youth, and he kept up the pastime to some extent until his sixtieth year, when a fall made it desirable for him to cease. We are told that he took no great interest in the live-stock ; but its existence must account for the unexpected entry in Bagshaw's directory of 1847—' Darwin, Charles, farmer.' One may attribute the source of this entry either to his own sense of humour or to the judgment of an editor without any. The accounts show no sign of aught but a comfortable simplicity ; the only conceivable extravagances, judged by modern standards, are the rather surprising quantities of coal and beer consumed by the establishment ; and against these must be set to-day's tendency to fuel economy and provision of a safe public water supply. The pastime of riding has been mentioned ; there were others. Backgammon with Mrs. Darwin provided a regular rivalry of many years' standing. As the children grew up, a billiards-table was installed, and Darwin himself played the game. An ancient of the village, in our early days there, claimed to have seen him playing cricket. But apart from these recreations, experimental work was for him definitely a pastime, or at least a relaxation from the effort of composition. For that reason among others he liked to keep several pieces of work in hand at the same time. Among the details of his daily routine set out in the *Life and Letters* there is reference to the remark sometimes made about noon—' *I've* done a good day's work ' ; but he carried his work with him in his mind ; the midday walk was also a time of thought. In his time the practice of reading aloud was more common than it is now ; he enjoyed good novels read to him by Mrs. Darwin, and it is consonant with his character that the story must end happily ; he was wholly averse from tragedy. He himself read stories to his children. He deplored his own loss, in later life, of the pleasure in poetry and art which earlier he had enjoyed, though he retained an interest in historical, biographical, and travel books. For music he had neither ear nor memory, yet he was a good listener and judge ; but music had at times the singular effect upon him of stimulating thought in his own work to an intolerable degree ; it was as though noble sounds stirred in him the sense of strife associated with his own noble conceptions, for composition in words never came easily to him.

Practically the whole of Darwin's life after his return from the voyage of the *Beagle* was affected by indifferent health. There has been a good deal of speculation as to the origin and nature of this. As to the origin, his constitution may well have suffered from the hardships of the voyage, and he was always a bad sailor ; moreover, while ashore in South America he had a serious illness the exact nature of which was never ascertained, though he himself was sometimes disposed to attribute his subsequent weakness to this. There seems to be no justification for invoking psychology as an explanation, as has been attempted ; nor does it appear just to write him down a hypochondriac (as he wrote once that some of his friends did, and as has been done since), if we accept the dictionary definition of hypochondria as a ' morbid state of depression for which there is no real cause.'

Certainly, in his case, the cause was real enough. There is in our possession a diary, in his own hand, of his daily and nightly state of health from July, 1849, down to the middle of January, 1855, when the diary ceased, although the sheet for the month is prepared with dates to the end. He used foolscap paper, a line for each day. The record is methodical according to his manner, and should be regarded as a result of his scientific habit of observation, exercised in this case upon himself, and not as an exhibition of nervousness, or self-pity, or any such weakness. Symptoms are recorded from which a medical opinion recently given to us is that the case was one of chronic indigestion, which should have been curable to-day, and might have been then. But it is known that Darwin had not much faith in doctors, and though he attempted certain cures, and admitted benefit from at least one of them (called the water cure), none gave anything like permanent relief. Simple as were his life and tastes, there is no evidence of any particular care in dieting.

During the period of the diary his health is recorded elsewhere as having been particularly bad : it improved somewhat in later life. If we take the five completed years, 1850 to 1854, and round the figures, we find that out of 1,800 days he only admitted to being ' poorly,' ' well not quite,' or ' well barely,' on 150 of them ; on the remaining days he was ' well.' But there were degrees of being ' well.' He was either ' well,' or ' well almost very,' or ' well very,' ' well very ' (the word ' very ' once underlined), or ' well very ' (with ' very ' twice underlined). These last days represented his highest standard, and were added up at the end of each month ; and out of 1,800 days there were 720 of them —' double dashes,' he called them, from the underlines. But even so, some of these last days included periods of discomfort : there are only 530 days out of 1,700 when no distressing symptoms are recorded (towards the

end of the period the recording of symptoms ceased). The number of best days fluctuated, now up, now down ; late in the period, against one good month's record, there is the note ' but I think I am not so strict as I used to be.' He was seldom kept in bed by illness, and then only (during the period of the diary) by something extraneous to his chronic condition, such as a feverish cold. Normally his nights were disturbed ; in a year of the diary he recorded only 100 nights as ' good,' without qualification; very often they were bad, wakeful,heavy,or otherwise uncomfortable. Actual pain is not recorded, save for occasional headaches ; there was also occasional sickness.

On this showing there seems to be nothing recondite in Darwin's state of health. No doubt it strongly reinforced his own and Mrs. Darwin's preference for a quiet country life, but the very last view which ought to be taken of his life is that which not infrequently has been taken—that it was the life of a recluse, concerned solely with his scientific work and his own physical condition. True, during the forty years of his life at Downe he was not often away ; but there were holidays, which were enjoyed, for whatever aesthetic pleasures may have left him in later years, that in beautiful scenery never did ; and it may be mentioned here that he was drawn to Down in part by the pleasant Kentish scenery which still remains with us. It is on record that any excitement, such as that of a visit to London, brought out the weakness of his health, and the diary shows that sometimes it did, though not always. More often there was apprehension that it would, and that is no matter for wonder. Sometimes, on the other hand, the excitement of scientific work helped to overcome bodily discomfort. But neither of these conditions labels the man as a hypochondriac.

Nor are his interests to be regarded as exclusively concerned with science ; they were, in fact, very wide. His scientific work certainly covered an immense field : it involved him in an extensive correspondence, and sometimes led him into unexpected byways, as when, at the period of studying pigeons in connection with inherited characteristics, he would hobnob with fanciers in Southwark, who called him ' Squire.' But apart from all this, he was always interested in men and affairs. In politics he was a Liberal, and his account books show subscriptions to the West Kent Liberal Association, and to other activities of the party. A visit by Gladstone and other eminent persons is cited in illustration of Darwin's extreme modesty ; what an honour, he felt and said, that so great a man should visit him, all unconscious of the judgment of the future as to which of the two should leave the greater mark on history.

Among the objects of his support was the Slave Redemption Society, as might be expected from his views, forcibly expressed, after visual experience of slave labour acquired during the voyage of the *Beagle*. There were contributions to the Anti-Corn-Law League, and to the Society for the Prevention of Cruelty to Animals, again to be expected from his abhorrence of cruelty and of suffering in any form. Perhaps also his contributions to a society for spelling reform are not unconnected with the slight difficulties of spelling correctly to which he himself was exposed, at any rate in earlier years.

A donation to militiamen appears in 1852, and in July of the same year an expenditure for fireworks on the lawn. The first was associated with the so-called ' French scare,' born four years earlier of the fall of Louis Philippe, and revived after Louis Napoleon became emperor ; the fireworks possibly celebrated the cessation of the risk of invasion. To that risk Darwin alluded, half humorously, in family correspondence ; he saw Down sandwiched between invading forces advancing from the Channel coast along the Sevenoaks and Westerham roads. Substitute the Germans for the French, and we who have lived at Down during the past few years may understand his foreboding. The formation of the Volunteer Force in 1859 was accompanied by the establishment of rifle clubs, and Darwin, himself a very good shot in youth, promptly supported the club at Bromley and equipped his eldest son and his butler to join the force.

The account-books help to illustrate the virtue of charity, which Mr. and Mrs. Darwin shared to the full. There are so many recipients of their help that only a few examples can be given. There are subscriptions to the Charity Organisation Society, the Mendicity Society, the Truss Society, and, among others, to the Chimney Sweep Society. The sympathy of Mrs. Darwin may be detected in gifts to the Society for the Protection of Young Females, and to the Kent Female Penitents (the exact titles of institutions, by the way are not always entered). Various charitable schools enjoyed Darwin's support ; so also did University College and London Hospitals, and others. Appeals for the alleviation of distress seem to have touched him very nearly, and they covered a singularly wide geographical range : thus we find entries in favour of relief in Ireland, the Highlands, Merthyr Tydfil and Coventry ; for the restoration of losses caused by inundations in Lambeth and France, and by a fire in Quebec ; contributions to funds connected with Neapolitan exiles, with Hungary and Poland, Syria, Circassia and

Jamaica, with an Indian famine in 1861, and to a ' wounded fund ' in 1870.

Help was constantly accorded to local causes. The Kent Agricultural Society, the Bromley Horticultural Society and the Orpington Agricultural Club were beneficiaries. Individual acts of kindness to inhabitants of Downe are still remembered by their descendants. The schools at Downe and at the neighbouring village of Cudham were supported. Darwin not only helped the finances of the Downe Friendly Club and Coal Club, but acted as their treasurer. As for relations with the church, the vicar who held the benefice of Downe during more than the first half of the period of Darwin's residence became his close friend, and Darwin helped him many times over such matters as church restoration and work in the parish for which advice and financial aid were needed.

Darwin's scientific views, for a time at any rate, divided the clergy against itself, and later in his life opposition to them was expressed from the village pulpit of Downe among many others. His attitude towards the Christian faith was, and to some small extent still is, misrepresented by assumption and through the process by which rumour grows. One opponent of his views would say ' the man must be an atheist ' ; the next would say ' So-and-so says the man *is* an atheist.' Yet he himself disclaimed this : he professed himself an agnostic, using the term in its simple sense of a ' not-knower.' He refused any part in controversy or in expression of explicit views, on the ground that he had not thought deeply on the subject, as a man must needs do before dogmatizing. There is never any sign of opposition to the Church. There were those who read this into his hesitation to comply with the request of a former shipmate on the *Beagle* for his help for the Patagonian Mission ; but that hesitation was due to his doubt whether the Fuegian natives were capable of receiving the message of Christianity. That doubt removed by evidence, his help was given, and we have the entries in the accounts as proof.

Down was the happiest of households. Darwin and his family were mutually devoted ; his upbringing of them was liberal, and they rewarded him amply. In their youth he helped them in their pleasures ; in later life, according to their several lights, they helped him in his work, and his acknowledgments to them individually are often found among his letters. He was the father of three Fellows of the Royal Society, as he himself, his father, and his grandfather were ; and that is a record held by no other family. These three sons of his, George, Francis and Horace, also received knighthoods.

It has been written of Sir James Paget, the great surgeon, contemporary and friend of Darwin, that he ' was utterly unlike the Victorian father of legend, self-important and pompous. He was at once Love and Authority, and these remained as indistinguishable in the minds of his children ' (*Henry Luke Paget*, by Elma K. Paget, 1939). So it was with Darwin, and incidentally there is a curious parallel between the distinctions achieved by the families of these two great men. For members of Darwin's family achieved the high positions we have seen : the Paget family included an eminent lawyer, two bishops, and a distinguished surgeon and essayist.

Darwin guided along the paths of science very many men whom he never knew ; but one so guided, besides his sons, had an intimate part in his life at Down. This was John Lubbock, afterwards Lord Avebury, who has been mentioned already. He was only eight years old when Darwin came to Down, but friendly relations between the two houses, and particularly between the boy and Darwin, were soon established and never broken. In later years Lubbock always acknowledged Darwin as his master in science. As Lubbock's scientific interests developed under this guidance, Darwin brought him into contact with other leaders in science, while, through Lubbock, Darwin was enabled to meet eminent men outside the scientific circle. The visit of Gladstone to Down House, already mentioned, is a case in point.

It is a matter of some regret that of all the portraits of Darwin now in the Down House collection—and they must represent by far the greater proportion of those extant—hardly one shows any side of his character other than that of the grave thinker. Only one—the *Vanity Fair* cartoon—presents him laughing heartily, as he was wont to laugh. Caricature as it is, it is said to catch its subject accurately in lighter mood. There is in a letter by one of Mrs. Darwin's sisters a delightful sentence describing Darwin after he and Mrs. Darwin had been staying with her. It runs, in true Victorian style : ' Charles is uncommonly agreeable, fresh and sparkling as the purest water.' This was written when Darwin was 47 years old, but it reads as if written of a boy. And time and again, despite his preoccupations with work and poor health, there emerges from the records a certain boyishness, though that is about the last description which those who know his work but not the man would apply to him. His personal charm was generally acknowledged, the outcome of the simplicity of his life and nature. Despite the fierce opposition to his views, there is no record of personal quarrels, unless it be that fastened upon him

by the wayward genius, Samuel Butler. But there is an immense volume of testimony to those lovable characteristics which radiated from the home life at Down which has been briefly depicted here. And for summary, let us recall Huxley's words from the obituary tribute to his friend which he wrote in *Nature*: 'An intellect which had no superior, and a character which was even nobler than the intellect.'

LONDON TRAFFIC AND THE LONDON PLAN

REPORT OF A CONFERENCE HELD BY THE ENGINEERING SECTION AND THE DIVISION FOR SOCIAL AND INTERNATIONAL RELATIONS OF SCIENCE, SEPTEMBER 12 AND 13, 1946.

THE Conference was held, by kind permission, in the Lecture Theatre of the Institution of Civil Engineers, Great George Street, S.W. 1. It was arranged largely by the Engineering Section of the Association whose officers felt, in common with others, that there had not, as yet, been sufficient scientific examination of the problems raised by various plans which have been prepared for the reconstruction of London, and it provided an opportunity for architects, town planners, engineers, traffic experts and others concerned to discuss the difficulties of this vast undertaking and to suggest some means of overcoming them. The conference was opened by Sir Richard Gregory, Bt., F.R.S., President of the Association, and was held in three sessions. Two sessions on the first day were devoted to the reading of papers; the third, on the second day, took the form of open discussion. Lord Latham, Leader of the London County Council, presided at the first session, and Sir William Halcrow, President of the Engineering Section, at the second and third sessions. Throughout the Conference there was an exhibition of plans, diagrams, charts and models relating to the subjects under discussion.

FIRST SESSION

Sir Richard Gregory, Bt., F.R.S.

THE British Association has, during the past 115 years, achieved substantial success in the promotion of scientific knowledge and its applications by research and by discussion and report, in its thirteen sections. One of these sections is that of Engineering, the officers of which have been mainly responsible in arranging the present meeting. It is being held here, by kind permission of the Institution of Civil Engineers, to discuss a problem of very real interest and concern to all of us, namely London Traffic and the London Plan.

As is well known, the London Plan consists of three main plans, the L.C.C. Plan, the Greater London Plan, and the City of London Plan, and there are others of special interest to transport experts which will no doubt be mentioned during the meeting. Viewed as parts of a whole, these plans may be regarded as a broad picture of what may be achieved in the next fifty years or so. They have all been submitted to the proper authorities and they are no doubt receiving attention. The complicated issues involved in replanning a built-up area of 1,800 sq. miles with a vast population are beyond the powers of a single body to comprehend and is not here being attempted. Though the outline may be drawn, and some specific proposals be made, there still remains the need for considerable economic, scientific and technical research. Many questions must be put and answered before the real work can begin in the right order and on the right scale. Scientists, especially applied scientists, can contribute to this vast enterprise and should be consulted to the full, and apart from the giving of technical advice there is great opportunity here for scientific discipline by which is meant experiment and research, the sifting and critical examination of evidence and finally the formulating or drawing up of conclusions and objectives.

We have here to-day a large number of experts who will no doubt raise many problems and, it is hoped, point to the solution of at least some of these problems.

We are grateful to Lord Latham, the distinguished Leader of the London County Council, for undertaking to preside at this opening session; and I have much pleasure in asking him to occupy the Chair.

Right Hon. Lord Latham

THE problems of London traffic have become more acute with every day that passes and with every additional vehicle that comes on the roads—and this despite the fact that the population of the County of London in March, 1946, was nearly one million less than in mid-1939 and in Greater London, including the County, about 900,000 less. People are, however, returning to London in larger numbers than was anticipated generally would be the case. Between March, 1945, and March, 1946, about 600,000 people came back to the County of London and nearly 1,300,000 to the whole of Greater

London. Moreover, there is evidence that many thousands more are only restrained from returning to London by the absence of housing accommodation. There is growing traffic congestion, delay, discomfort and danger, which will increase in the future with the inevitable growth of traffic on the roads.

A road system originally designed to cater for horse-drawn vehicles is in process of slowing down the movement of mechanical vehicles to the speed of the horse—a cynical instance of the power of yesterday over to-day, and of our failure to match the progress in one field with that in another.

It is now generally recognised that there can be no satisfactory replanning and reconstruction of London without a fundamental replanning and reconstruction of the ways and means for the free and speedy movement of people by road and rail, on the surface and beneath.

As Leader of the L.C.C., I am naturally chiefly concerned with the County of London and the County of London Plan, but I recognise that the solution of the traffic problem of the County is closely bound up with that of Greater London. My observations this morning will, however, necessarily be principally related to communications within the County.

The authors of the County of London Plan fully recognised the fact that communications constitute an essential element in comprehensive city planning and that the road system must play a dominant part in the lay-out of any well-ordered community, and also that roads must be co-ordinated with railways. The County of London Plan contains a synthesis of a replanned road system involving vast projects and immense changes. Nor are the railway proposals less thorough-going. Wisely, the authors of the Plan suggested, and the L.C.C. approved, that the railway proposals should be considered by an independent Committee qualified to examine the technical and operational aspects of their railway proposals. The Committee presided over by Sir Charles Inglis has presented its report on these, which report lacks nothing in boldness of conception or amplitude of expenditure.

The L.C.C. has accepted the proposition that one of the major defects of London is an obsolete road system, with its consequent traffic congestion. The Council has accepted the proposals for, *inter alia*, ring roads, with linking radials, and has settled in principle a short-term programme for immediate post-war execution, as materials and labour (including technical staff) become available and conditions otherwise permit. The Council is also working upon a second programme to be carried out over a longer period.

The short-term programme embraces new roads, improvements of existing ones and improved intersections by way of roundabouts and otherwise. It is estimated that the cost of this short-term programme is of the order of £20,000,000. Upon some of the proposals in this immediate programme agreement has been reached with the Ministry of Transport and the remainder have been and will continue to be discussed with the Ministry at the various stages of design and development. Consultation with the Ministry does not, however, end here. Each housing proposal affecting a major road proposal has to be considered jointly with them and, where necessary, agreed measures taken to safeguard such proposal. Discussion has also to take place on other development proposals affecting existing highways.

Owing in large measure to shortage of staff the amount of work which can be done on the ground during the next year is not likely to be great, but an appreciable number of street improvements can be envisaged in connection with housing development. Although these will necessarily be of a piecemeal character, they will fit into ultimate plans. Work is expected to be resumed early in 1947 on at least one major improvement approved by the Council before the war (Notting Hill Gate). Extensive progress must wait somewhat on housing progress, because most road works destroy some houses.

It is not possible to give the cost of all the schemes under consideration, because no estimates have been so far prepared in many cases, but it is well over £100,000,000 and covers a long-term policy of systematic improvements. The estimated expenditure on schemes which may be begun in the initial period is approximately £8,000,000.

I can assure this Conference that neither the Ministry of Transport nor the L.C.C. is under any dubiety as to the urgency of getting on with the work of improving the road system of London. But we must be careful that the urgency of the present does not lead us into mistakes for the future. Whilst appreciating that, as Shakespeare says in 'Hamlet', there is danger in this matter, as in others, 'of thinking too precisely on the event,' nevertheless, there are weighty factors which we cannot afford lightly to disregard, when we reflect that we shall be laying down a road system which will endure for many, many years. Nor can we ignore certain immediate considerations, some of which are transient and others not so.

Take, for example, the ring roads contemplated in the County of London Plan—which of these is to be arterial and which sub-

arterial? In determining this difficult question ought we to disregard the fact that the choice of the one as against the other may mean the destruction of many buildings of great historical value and/or architectural beauty? Are we to ignore that a decision one way may result in a reduction of the all too insufficient open spaces in London? At a time when housing accommodation is so desperately short in London—there are over 200,000 applicants for dwellings in the County of London alone—could any responsible authority contemplate proceeding with road projects, however desirable and urgent, which will involve the demolition of large numbers of dwellings, mostly occupied by people in the lower income groups, and which would result in turning out families who would have little or no chance of securing alternative accommodation, except at the expense of others who at present are without proper homes.

Furthermore, could we at this time lightly contemplate the demolition of large tracts of industrial and commercial buildings until others are available?

Then there is the question of what would be the effect, both architecturally and socially, of stretches of high-level roads and viaducts. Are we to seek to lessen the extent of the existing drab and dreary railway embankments and cuttings, only to create others for overhead roads and viaducts? On the other hand, need overhead roads necessarily be unsightly, or otherwise socially undesirable? Should we experiment first on a selected stretch of road and, if so, what delay will this involve?

Again, if the community idea is to be the general basis of the replanning of London and if civic and associated life is to be preserved—and surely we must do our best to preserve and foster this—then ought we to project main roads in such a way as would seriously break up community units?

These are some of the practical difficulties which face those responsible for reconstructing and improving the road system of London. To state them is not to run away from them. They must be faced and surmounted with boldness and resolution. But impatience, whilst a salutary, compulsive aid, is also a dangerous master. London is here with all its faults and disabilities: its disorder and its muddle: but it is here and its people are here. It is not a *tabula rasa* where from the drawing-board one can plan the London we would desire without regard to what it is. London must be replanned whilst the life and activities of its teeming millions go on: they cannot be stopped, nor can they be greatly slowed down.

This is no apology for complacency. No body, whether it be Ministry or Local Authority, dare neglect to do everything that is practicable to resolve the problems of London traffic as rapidly and as extensively as possible. But we must realise that the proper solution involves many facets of community living. Movement is of the essence of life—the more gregarious the people, the more they need to move, as it were, within their own encampment. Planning is a design for living—good living, in ease and comfort—why, indeed, should man be uneasy and uncomfortable—and convenient ways of movement are an essential element, if life is to be flexible and gracious and acceptable.

So those concerned with the practical responsibility of resolving these problems of London traffic will be grateful to the British Association for arranging this Conference, where the different and sometimes conflicting elements of the problem of communications can be discussed by experts in the various fields: Roads, Railways, Air Transport, Control, Safety, Planning, Architecture, Engineering, Operational—all of them.

As Leader of the L.C.C., which carries a major responsibility for doing the job in the County of London, I can only say that I shall greatly welcome any guidance and counsel this Conference can give to us. Whatever we do will be wrong in the view of some people. History viewing our actions from the restful arm-chairs of freedom from responsibility may condemn us. That is the privilege of to-morrow over yesterday: that, perhaps, is how to-morrow gets its own back on yesterday. Albeit, we must remember that we are planning not for only to-day, but for to-morrow.

We must also bear in mind that it is the people who must live in the planned city and who will use the roads and the railways and other forms of transport. We are planning not for sheep, but for lively men, women and children—conscious, virile individuals, who want to live out their lives in the heat of blood, as persons, not as robots.

With these thoughts in my mind, I have great pleasure in asking Sir William Halcrow to address us.

Sir William Halcrow

THE meeting of the British Association which was begun in Dundee in 1939 was abandoned in view of the threatening political situation in Europe. No full meetings of the Association have been arranged during the War, but the first post-war meeting will be held, again in Dundee, in 1947. Any section of the Association may organise a meeting at any

time and the Organising Committee of the Engineering Section decided that considerable interest would be aroused if a conference were held this year in order to discuss London Traffic Planning, a subject which has been so much before the public in recent years.

It is not the object of the Conference to propose specific plans, but to discuss the broad principles which govern the planning of any improvements in or rebuilding of large cities in so far as such planning affects traffic and its needs. It is my duty to introduce the subject only in a general way as eight experts in the different aspects of the problem have kindly submitted short papers which will be read to-day and which we hope to discuss at a session to-morrow morning. I hope it may be possible to draw up some general conclusions as a result of the discussion.

It will be generally agreed that more road space is absolutely necessary in London if traffic is to be adequately served. Even with the present limited number of motor vehicles, congestion in certain parts of London is becoming almost intolerable. Moreover, private cars are being parked in the streets in large numbers and occupying valuable space which should be available for its proper function, namely, the passage of vehicles. This raises the important question of whether the convenience of the few is to be catered for rather than the needs of the many. Pending the construction of new roads and car parks, will the Authorities be compelled to prohibit private cars from entering or parking within a circle embracing the heart of London. The important problem appears to be where to locate the new roads and in doing so an important question is whether the roads are to be at present street level, underground or overhead.

Congestion arises to-day from the fact that streets cross at the same level and we therefore turn our minds to the alternatives of underground or overground crossings and it is a discussion of this important matter which will, I hope, be evoked by the papers which are to follow.

The advantages of overhead roads appear to be that they are easy to construct and that no drainage or ventilation is necessary, nor the removal of underground services. An objection made is that overhead roads may be unsightly and, therefore, if roads are underground where they cannot be seen this objection would be removed.

Those of us who have to deal with underground London know of the mass of public utility services material such as electric cables, sewers and gas and water mains, not to mention railways which exists below ground, much of which would inevitably have to be removed before sub-surface roads could be built. Personally I do not think that overhead roads need be unsightly, and when recently in Stockholm, I saw one or two examples which do not offend the eye.

As a matter of interest, I have had some slides made of a scheme for overhead roads which was prepared by my late partner, C. S. Meik, for the Royal Commission on London Traffic in 1904. The plans and sections of the scheme he and his colleague, the late Mr. Walter Beer, prepared, make, I think, interesting reading to-day. These engineers undoubtedly had vision, and had their proposals been carried out the traffic situation would have been much less serious to-day.

Another matter which I hope will be the subject of discussion is the proposal made from time to time to group the terminal railway stations north and south of the river. If we omit Charing Cross and Cannon Street termini, which are really extensions of London Bridge, we find that London's main line railway stations are situated on a ring surrounding the heart of London. This is a very convenient arrangement. It is no doubt true that many of the stations ought to be rebuilt, but that is not surprising since most of them were constructed a hundred years ago. If some stations are grouped, traffic conditions in the immediate neighbourhood will become very congested. Decentralisation and not centralisation I suggest is more desirable so as to distribute the flow of traffic to and from a station as much as possible.

It has also been proposed that large terminal stations should be sunk below ground, but in this case I do not think one can generalise in expressing an opinion. If such a station could be approached by roads at an easy gradient there would not appear to be any serious objection. Paddington, for example, is well below street level. But, is it desirable that any large main line station should be approached by escalators for passengers and lifts for luggage ?

We shall, no doubt, have views expressed on the retention or removal of Charing Cross and Cannon Street stations and on the relative advantages of underground railway and transport. The subject is a wide one and many interests will have to be considered before a satisfactory solution of the difficulties can be found.

Another feature of planning which has received some publicity in the press is the desire to concentrate certain activities in one district. For example, it has been suggested that there should be a music centre where concert halls would be concentrated. If we take this idea literally, traffic from all

parts of London would converge to a point at certain periods and one asks whether it would not be better to set up a number of music centres well apart so as to spread the traffic and also reduce the distances which some of the public would have to travel.

Sir Alker Tripp, C.B.E.

Traffic

1. General

In post-war town-planning a well-designed road plan is essential. Our present road system is *not* well designed ; the measure of its defect is proclaimed by the fact that, in the ten years before the war, more than two million people were killed or injured on the roads of Great Britain.

In order to qualify himself for the type of planning required, the town-planner must first of all realise what is causing these road casualties. The root cause is perfectly simple. Whereas the railways provided suitable tracks before high speeds were developed, no such provision was made for motor traffic. Speeds like those of the railway were developed on roads built merely for horse-drawn traffic.

Look at London. All the roads, even Kingsway and Aldwych, were built in the horse-traffic era. In addition to that, the whole road system is like a railway without sidings. How would the railways work if there were running lines only ? All circulation would stop.

Let us face the facts. The change from horse-drawn to motor traffic was a revolution and nothing less than a corresponding revolution in roads and road user will suffice. The needed revolution is still awaited. This can only be brought about by investing millions of money.

There are two aspects of the problem : circulation and safety. These can be taken separately.

2. Traffic Circulation

Forty years ago we thought that London traffic was dense enough, and wanted more room. But look at it now. Compared with then, the traffic at Hyde Park Corner has been trebled. In Trafalgar Square, Piccadilly and Holborn it has been doubled. At Hammersmith Broadway it has been trebled.

No one can put a quart in a pint pot. These London roads of ours will carry so much, and no more. We have used traffic signals, one-way workings and so on, but the fact is that the traffic is often close upon saturation point. In Piccadilly, saturation point is sometimes actually reached, between Bond Street and Berkeley Street, where six roads enter Piccadilly within a length of 200 yards.

If we don't hurry and get some modernity into London, we shall either see London traffic at a standstill, or a London closed to some classes of traffic (e.g. private cars). And either would be a calamity, and an equal confession of utter failure. Two obvious things have to be done. First, we *must* have accommodation for standing vehicles. The Interim Report of the Road Safety Committee says the Highway Authority is responsible, and that seems to be the case. In London we want accommodation under squares, under parks, under buildings, in multi-storeyed buildings and on open sites wherever available. The parking spaces must be at frequent intervals : the accommodation must be on the spot where it is wanted.

Secondly, we must keep the through traffic from going through Central London. This can only be done by an elevated or sunken ring road. A ring road on ground level wouldn't have a hope of filling the bill. Take a journey from King's Cross to the Elephant. Straight through the centre the journey takes 16 minutes. Round the " A " ring (County of London Plan) on ground level it would take about 20 minutes. On an elevated or sunk ring road it would take 7 minutes. That road at separate level is what we want. We don't want clover-leaf layouts at junctions, but simple roundabouts, crossed at separate level by the major road, and with connections between the major road and the roundabout by means of ramps. These suggestions were made to the authors of the County of London Plan (cf. para. 212). How it can be carried out is shown in the book *Road, Rail and River in London*, which is a Report of the Royal Academy Planning Committee.

3. Road Safety

Casualties are extremely high. Some thirteen years ago it was assumed on all hands that dangerous driving was well-nigh the sole cause of casualties : but that has been proved to be quite wrong. Strict analysis some years ago showed quite a different result. Dangerous and careless driving of a prosecutable order were found to be responsible for less than 15 per cent. of the total casualties. The vast majority are due to the magnifying effect of vehicle-speed upon what may be described as human errors, namely inattention or thoughtlessness, not only on the part of drivers, but of pedestrians and pedal cyclists also. Of these aggregate human errors, about a third are on the part of drivers, a third on the part of pedestrians, and a fifth on the part of pedal cyclists. However

much motor drivers are regulated, two-thirds of the problem will remain virtually untouched. Human error is what we are up against, and we have to plan in such a way as to counter it.

When we look at the big casualty maps, one thing is very clear. The great majority of casualties are ribboned along the main traffic routes; and pedestrians represent 60 per cent. of the fatalities in London.

Only when inhabitants are 'exposed' to the traffic do they become road casualties. Pedestrians are not 'exposed' to railway traffic because it is fenced off from them, and they from it. But pedestrians are very much exposed to road traffic in Oxford Street, and it has a shocking casualty record. Oxford Street is a traffic artery. If we cannot withdraw shopping crowds from a traffic artery, we must withdraw the traffic and send it elsewhere. We must, on the largest possible scale, divert the main traffic flows from the daily haunts of the populace. It can be done.

4. Planning for Traffic

The first step towards planning is to get rid of the nondescript road: every road must have its own definite and clear-cut character and office. Roads fall into two classes, the functions of which are not only entirely different, but are mutually antagonistic, viz. (i) roads built as traffic conduits, and (ii) local roads which are roads intended for residence, shopping, business.

In planning for the future, we must take account of three generic types of road and three only, viz.:

(i) arterial, *i.e.* the motorways which are essential but are not as yet provided;
(ii) sub-arterial, *i.e.* the other main traffic conduits—now and hereafter;
(iii) local or minor.

The local roads can be divided up into as many categories as the town-planner may desire (shopping, residential, etc., etc.) but generically—for traffic purposes—all such roads have the same status, viz. that of a local road. On arterials and sub-arterials, the interests of the traffic will be regarded as absolute; and all other interests must go to the wall. In the case of the local roads, on the contrary, traffic considerations must be entirely subordinated to the needs of the local frontagers and pedestrians—in other words, the local populace.

When this scheme is mapped out for any area, a sub-arterial grid is created on paper. The spaces between the sub-arterials of this grid will comprise little local systems of minor roads. It is in these 'precincts' that industry, business, shops and residence will be located, quite away from the through traffic. The local roads in each precinct must be so designed—by means of obstructive layout if necessary—as to deter the through-traffic from using them.

5. Road Design

The designer of to-morrow (if not of to-day) will demand, before he makes his plans, a very clear definition of the purposes which each particular road is to serve. He is bound to revolt against the inefficiency of the three-purpose main road and the nondescript road. When a road for fast motor traffic is wanted, he will reject the hopeless handicaps of old-time frontages, innumerable junctions and teeming roadside population; he will see that a new road is essential. When he is designing the streets of a precinct he will ensure that the interests of the local populace are paramount, and that the traffic is effectively controlled by his layout. His shopping streets will attract shopping traffic only, because his layout will be such as to offer no inducement to through traffic. Wherever his touch is felt, in fact, traffic will be controlled by layout. And, in the last stage, the control of traffic will be virtually automatic and mechanical.

6. Things Now Demanded

What now is the present programme?

(i) *Sidings must be provided.*

Tracks without sidings are totally inadequate. The Highway Authorities—it seems clear—are under an obligation to provide the sidings, as an essential part of the highway system.

(ii) *A sharp and absolute line must be drawn between the traffic conduits and local roads* (i.e. *the roads of the neighbourhood units, where people live, shop, and have their business and amusements*).

There must be no overlap between the two classes of road. The overlap causes vast numbers of casualties. There must be no compromise as to this in future plans. Compromise means casualties.

(iii) *We MUST divorce Development from Traffic Roads.*

Such a divorce can only be complete in the case of new roads. But we must do our very best on all existing traffic roads also. The past cannot be undone, but the evil can be prevented from extending. All existing roads which will be future traffic roads (however humble they may be at present) should be scheduled at once and kept entirely clear (*a*) of development, and (*b*) of unnecessary new access. All future development must be confined to *ad hoc* local roads.

(iv) *We MUST stop the wanton exposure of pedestrians to traffic.*

The pedestrians, who represent 60 per cent. of the total fatalities, would not become road-casualties had they not been ' exposed ' to road traffic. That ' exposure ', therefore, is a factor which needs to be attacked at every opportunity. On existing roads there is a great deal of exposure, but on new traffic roads there need be none. New roads *created to meet the needs of motor traffic*, as distinct from roads built for housing, etc., are no place for pedestrians. Pedestrians have plenty of routes already, and any new ones that they require should be kept quite away from main traffic routes. For pedestrians, traffic roads are the very worst place conceivable. A recent Committee recommended that, on new outer ring roads, provision should be made for pedestrians, although—as it admits—those roads must be ' so designed as to compensate for the detour by higher speeds.' That will not do at all.

(v) *We MUST get rid of horse-and-cart mentality.*

It is the horse-and-cart mentality that continues to expose pedestrians, quite unnecessarily, to express-speed traffic. It is the horse-and-cart mentality that makes people cling, for example, to such things as Service Roads. The service road has never (I believe) been defined. The service it renders is to enable ill-sited buildings to create ' ribbon-development ' along traffic roads. Traffic roads want no such service. That is the very worst service that could be given them. And here again compromise means casualties.

The clean cut is essential. The change from the crawling horse-and-cart to the express motor car was a revolution. A corresponding revolution in roads and road user is the *only* hope.

Prof. W. G. Holford

Transport in relation to Town and Country Planning : with particular reference to Greater London

1. Broad Planning Objectives

The demands of safety, as well as those of engineering efficiency in transport do not admit of compromise. As Sir Alker Tripp has remarked in his book on *Town Planning and Road Traffic*, ' . . . the pursuit of safety must be unyielding, and in the long run the boldest measures will almost certainly be the cheapest. . . . It is futile to plan for hygiene and amenity while at the same time forgetting the ever-present risk of sudden death.'

Most of us would agree with these principles ; and some of us will think at the same time of the many occasions when, for one reason or another, they have sadly failed in practice. There are many admirable plans at the present day for roads, railways, motorways and airfields, ranging in scale from those for Greater London or the country as a whole, to particular problems such as Billingsgate or Charing Cross Station. Until a balance of interests is struck, none of these schemes can be proceeded with. One may call this balance a compromise ; and it is true that planning often involves it.

Occasionally it is a question of choosing between a lesser and a greater improvement, which turn out to be mutually exclusive. More frequently it is a case of general physical improvement *versus* economic disturbance. The life of the community may survive the change in environment and be the better for it : in residential areas this is almost invariable. On the other hand a commercial area may be improved out of existence. There are not many instances that one could quote in this country ; but the fear of it is a powerful factor, sometimes underrated by experts. For example, it is not in the least difficult to conceive a traffic plan for the City of London, which would remove congestion and at the same time injure the activities that cause it. Amenity, hygiene, scenic effect, traffic flow, and even safety, cannot be the dominant consideration in a case like this : for they all depend on prior settlement of the economic function of the area and its main uses.

In a free country—even one committed, as ours must necessarily be, to an increased measure of central planning—a balance of uses in other than purely residential zones is not easily arrived at. And the first point I would like to put is that specialised measures and the carrying out of bold traffic improvements should not be considered as something independent of the economic life of the areas to which they are applied, whether this is carried on in shops, offices, warehouses, factories, or farms. They should, in fact, evolve from it. *But once the objectives are agreed, the bolder the measures the better.*

The second point I should like to mention has to do with the quantity of traffic. One of the results of successful town and country planning should be a reduction in the number of unnecessary journeys, particularly those between living-place and work-place. When all allowances are made for the journey to work as a necessary ingredient of the economic freedom of the worker, it is still true that far too high a proportion of these journeys are outside the happy mean.

Either the houses and workshops are so

mixed up that they get in each other's way, the streets become dangerous, and segregation of road user is made almost impossible ; or else the housing estates are mere dormitories and not only one but all the wage-earners in a family have long, tiring and expensive journeys to make. The total number of people employed in transport and distribution, as compared with those employed in manufacturing industry and agriculture, is very high. (Experts on the distribution of manpower may even say it is unnecessarily high [1].) In any case it is a function of town and country planning, by correct zoning, by a more balanced distribution of industry and commerce, by urban redevelopment and the building-up of satellites, to reduce travel costs and travel time both in Greater London and in rural districts.

This is one side of the picture. On the other are two facts which both point to increases in travel. The first is the effect of improved standards of living which it is the object of planning to promote. This is expressed clearly in Chapter V of the Report of the Railway (London Plan) Committee of 1944, which comes to the conclusion that the volume of travel in the London area, as measured in passenger journeys and still more in passenger-miles, will continue to increase. ' Experience shows,' they say, ' that as income rises the demand for transport rises more than proportionately, irrespective of transport to and from work. No doubt this tendency will continue and the institution of Holidays with Pay will reinforce it.'

The number of licensed road vehicles is approximately the same now as it was in 1939,[2] an increase of over 2,000 per cent. on what it was in 1910. The startling figure quoted by the Alness Report [3] was that the number of motor cars in Great Britain was then increasing by about 1000 every day. This may happen again, though perhaps not to quite the same degree so far as the home market is concerned ; and apart altogether from statistics (which are usually only as significant as they are made to be) it stands to reason that a country which works hard and plays regularly, which is aiming at full employment, and which must remain strategically equipped at all points, is a country to which progress in all forms of transport is vital.

It seems then, that the amount of ' uneconomic ' travelling reduced by the intelligent town planning and factory location, will be more than compensated by the increase of necessary transport, and by holiday journeys. So far as roads are concerned, town planners have to budget for a doubling of motor traffic in anything from ten to thirty years—depending on circumstances.

Suppose we use this estimate as a basis for reconstructing the street-system of the congested urban area of Central London. We come up against some curious consequences. In the first place the cost of doubling the effective provision of public services, and at the same time maintaining a high standard of comfort and convenience, is enormously greater than the transport undertakings themselves can face. (This is true of airfields as much as of underground railways.) But private road vehicles are a constantly filling pool. When new channels are opened they rapidly become flooded. And the result of increasing the road and the parking facilities of a redeveloped central area may simply be the attraction of more vehicles into it, many drivers bringing their own cars instead of using public service vehicles.

To a limited extent these difficulties will cancel out ; but I should guess that nearly all town planners concerned with built-up areas are faced with the necessity of costly improvements both for public services and for the accommodation of private and business cars in increasing numbers. *And this is so even in places whence it is proposed to decentralise both population and industry.*

So the broad planning problem may be summarised as follows :—

(1) a building that is all stairs and corridors is badly planned ; a town whose circulation is improved at the expense of its accommodation may become a liability ;

(2) there should be no compromise on traffic measures once the main objectives are agreed, but there should be a comprehensive weighing up of *all* the factors on a broad economic basis before schemes are worked out in full technical detail ;

(3) traffic and travel will increase in any case, and constantly higher standards will be demanded ;

(4) in built-up areas, even where density of population is to be reduced, the cost of essential improvements is beyond local resources ; and for this reason amongst others, the traffic system is of national, or at least regional concern.

The conclusion is inescapable : the traffic problem must be studied comprehensively—

[1] Very roughly :

Manufacturing Industry ..	6½ million	Figures for May 1946
Agriculture	1 million	
Transport & Distribution	2½ million	

[2] 3,189,000 current at August 31, 1939. (Return No. 132, Ministry of Transport.)

[3] House of Lords Select Committee on Road Accidents ; quoting the Minister of Transport : 1938.

even more comprehensively than in that remarkable document, 'The Highway Development Survey, 1937,' known as the Bressey Report; and then the most urgent needs, and not necessarily the most exciting projects, must be decided on, budgeted for, and put in expert hands to carry out. Less urgent improvements may be put into the category of 'as and when'; and it is surprising what opportunities occur for ingenious solutions—many of them arising from the accidents of war damage, and from the acquisition of large redevelopment areas by local authorities under the Town and Country Planning Act of 1944.[1]

Even the most general review of transport needs in and around Greater London would result in varying orders of priority on the part of those who made it. I can only say, as one who is not expert, that the following improvements seem to me to be the most wanted by what I might call the "traffic consumer'—which is perhaps a slightly idealised conception of the 'traffic customer.'

Outside the town: fast arterial roads altogether avoiding built-up areas; improved rail facilities to railheads in the more 'inaccessible' parts of the country, such as East Anglia, and also between Central London and certain satellites, both new and existing.

Inside the town: further provision for peak-hour workers' traffic, especially to concentrated commercial areas (e.g. relief of Northern and Central Underground Lines); improved access to the countryside and to airports; improvement and linking-up of main railway and bus terminals; segregation of arterial, sub-arterial and local road traffic in a recognised system.

2. Transport and the Redevelopment Plans

So far I have mentioned nothing but *caveats* and difficulties which from a town planner's point of view require to be met before the details of any traffic system are worked out. I believe that, as in the case of buildings, trouble spent on the programme and planning of a combined operation saves not only time but recriminations afterwards. But once the main arguments are over, delay and timidity bring nothing with them save expense, exasperation and danger.

In the layout of roads, the Report of the Departmental Committee set up in 1943 by the Minister of War Transport under the chairmanship of Sir Frederick Cook, has shown conclusively that the principles of traffic flow and those of road safety are not only compatible but identical. There are aesthetic questions, relations of building blocks to roads and road junctions, and proposed treatments of verges and islands, on which the town planner will wish that the Committee had put forward views as advanced as those on traffic itself; but on the soundness of the general principles, as on those set out in Sir Alker Tripp's volume that preceded the Committee's work, there can hardly be two opinions.

I think most town planners, if not the sociologists, will agree with the conception of the 'precinct,' and with the principle of traffic segregation in terms of destination, direction and class of user. But so long as there is no correspondence between the use, volume and traffic capacity of adjacent buildings, we cannot hope for a reduction in the number of all-purpose roads.

I should like to add only one comment, and that relates to central commercial areas. the barometer of trade is sensitive, and in order to avoid unnecessary fluctuations it is as well to decide quickly which improvements are essential forthwith, no matter what physical difficulties are involved, and which must wait on changes in commercial activity and the gradual obsolescence of buildings. These changes occur far more quickly than is generally realised. In the City of London, for example, during the past century or so, about one quarter of the total properties have been redeveloped over each period of thirty years.[2]

Moreover, the useful life of commercial buildings of most categories (though not of all) is growing less, even though their structures are on the whole more fireproof and more durable. Because of some confusion between the economic and the structural life of buildings, there has grown up a rather excessive respect for the steel-framed structure, which is commonly assumed to be impossible to move out of the way of a street improvement. In fact, it is the historic masonry which is the more difficult to move; and in the course of the last few months, Dr. Holden and I have often wished that an engineer with a taste for such enquiries would estimate the cost and possibilities of bodily removal of small but valuable ancient monuments to new and prepared sites a few yards distant. City churches such as Wren's *St. Magnus, London Bridge*, or Dance's *All Hallows, London Wall* are obvious examples.

In spite of the advantages which technique combined with courage will secure in the redevelopment of streets and traffic junctions,

[1] The areas involved are sometimes considerable, e.g. the Poplar-Stepney area for which application is now being made under s. 1 of the Act by the L.C.C. is 1,960 acres, immediately east of the City of London.

[2] See the map showing periods of redevelopment in the excellent Survey carried out by the City Engineer and Mr. Gerald Eve in 1936, for the Court of Common Council.

the fact remains that existing uses, tradition, social habit, and business convenience, will very often lead the town planner to log a street improvement as long-term. But as the street or junction is still a necessary element in the traffic system, it has to remain for perhaps fifteen or twenty years as an all-purpose road. It may contain shops, public buildings, warehouses and all sorts of access. And in such a case it seems better to make provision for such through traffic as can reasonably be drawn off, and then frankly to acknowledge the street as a slow one, provide reasonably generous pavements—perhaps under an arcade where this is the only practicable method—and desist from piecemeal setting back of frontages and the erection of guard-rails. In other words, it may be better to carry out radical improvements now or later on, rather than attempt gradual half-measures which will produce an illusion of speed and safety and make pedestrian and motor driver careless of accident. Although the street will continue to be congested and slow there is *some* promise of greater safety in the general recognition of that fact; and meanwhile, as new one-purpose roads come into use, the dangers incidental to mixed traffic on the old road will lessen.

Apart from this one concession to delay in the interests of ultimate real improvement, one must agree that no compromise over the road-traffic principles set out by the Departmental Committee would be asked for by the town planner. But the acid test, of course, is the application of the principles to actual town plans, and their execution in practice.

Whatever individual views there may be on the road system for London outlined in the County of London Plan—on the feasibility of Cross Routes 'X' and 'Y,' or whether the 'A' or the 'B' Ring should be arterial—it must be conceded that the plan knits together what one may call the Tripp safety principles, and the Bressey road framework in masterly fashion. Here we have a comprehensive physical plan, now made almost total by the addition of the Greater London Plan. These plans do not attempt, by taking a bird's eye view, to show the way out of a maze; they take the maze itself and reduce it to order. The order is still complex but it is at least conceivable; and those of us who have flown over and round London will admit, I think, that the pattern of the present metropolis is utterly beyond comprehension.

The great achievement of these plans, to my mind, is reflected in the method they establish for *reorganising* the urban fabric—in their own words, '. . . for disengaging the communities, to mark more clearly their identities, to preserve them from disturbing intrusions such as streams of through traffic, and generally to reconstruct them when reconstruction is necessary owing to war damage or decay.'

And I think they are valuable also as a means of bringing to a head issues of doubt, such as the provision of motorways or the removal of restrictive railway viaducts—proposals which are part of the general objectives of town and country planning, but which involve a special technique whose experts may find different means of reaching the desired ends

A good example of this is the report of the Committee [1] set up early in 1944 to investigate the 'technical and operational aspects of those suggestions made in the County of London Plan which relate to the main line and suburban railway system of London . . . bearing in mind that these suggestions are intended to contribute towards and form part of a comprehensive scheme for the re-development of the area in question.'

I am not competent to discuss the technical merits of this valuable report. I can only say that having studied it, it seems to me to promise all, and more than all, that the planners could ask of it; and no doubt the amended proposals would be far more satisfactory in operation than those tentatively put forward in the County of London Plan. I would not even cavil at the admonition in para. 4, which says—'We appreciate that, from the planners' point of view, it is generally desirable to abolish viaducts. But the railways carried by these viaducts should be regarded as essential instruments of transport rather than as obstacles to development.'

I would gladly pass that question-begging statement, for the sake of the constructive and imaginative proposals which follow. Through-working is substituted for loop-working. Electrification and inter-running are endorsed in modified form, and the plea for removal of surface stations, bridges and embankments on amenity grounds, is reinforced by practical considerations of the improvement in transport facilities which would make this removal worth while. Out of this comes the proposed scheme for a new system of underground railways, the re-siting of London Bridge Station at Tower Bridge Road, and the new terminal at Waterloo Junction—a scheme which, if carried out, would not only add to the traffic convenience of millions but would create, in fact, a second City of London on the South Bank, complementary to the historic Square Mile on the North Bank.

[1] Railway (London Plan) Committee: Report January 21, 1946, *op. cit.*

To achieve this great joint operation, three further developments must occur: first, the financial burden must be assessed in terms of money and manpower, and in relation to national as well as metropolitan resources; secondly, the detailed plans must be revised to take advantage of the proposed traffic facilities and improvements, and to locate more exactly the sites of deep-level stations and the necessary traffic links on the surface; and meanwhile, as the Committee themselves recommend, a technical organisation would have to be set up to investigate the proposals as a whole from the engineering aspect, and to study underground conditions.

For new roads, equally, decisions in principle are still awaited. But the financial situation here is slightly different, in that road users are likely to pay in motor and fuel taxation some £87 million over an average year. This means that 200 miles of new roads in London, and 300 miles in other towns, £200 millions' worth of improvements to existing roads, 1,000 miles of motorways on the basis of the County Surveyors' scheme, maintenance for the lot over a period of ten years, and loan and administration charges at the rate of £15 million a year, could all be carried out, theoretically, on ten years' revenue from the taxation on motors and fuel. (In fact, about three-eighths of the total of £870 million would come from the Rate Fund, while about three-quarters of the revenue from motor taxation would go into the general exchequer.) I only quote these rough figures to show that, if London's share of the national road proposals were taken to be £35 million a year—on this ten-year basis—and if to that is added £25 million a year for railway improvements—on the thirty-year basis of the Railway (London Plan) Committee—a total of some £60 million a year would have to be found for keeping London moving, and preventing it from seizing up.

There would, of course, be incalculable savings as a result of reduced traffic congestion, the cutting down of road accidents, and, on the whole, the appreciation of land and property values. All these are long-term investments. There would also be gains in amenity—positive gains in convenience, comfort and civic dignity; negative gains in the removal of a good deal of noise, confusion, and strain.

If, in addition to the economic necessity of easy circulation in this island of ours, these other gains are to be secured, co-ordination of land-use, architecture and traffic are clearly required. The combined operation is becoming more and more necessary, not only in the administrative and executive fields, but also in that of research.

To take only a few examples, we need to relate the origin and destination census for traffic to the social and employment surveys of the places involved; we need far more data on the amount of parking space required by shops singly and in combination; we should have experimental intersections, lengths of carriageway, bus stops, subways, shelters, etc., in normal use for test purposes as advocated in the Alness Report—possibly in the new towns now proposed by the Minister of Town and Country Planning; we should promote improvements in the design of such things as multi-floored garages and mechanical car-parking; and we should investigate the most suitable treatments and use for the interior of roundabouts in central areas.

All these studies require the collaboration of experts of different kinds; and they are also of enormous interest to the general public. In fact the stimulation of interest in research and improvements might have as salutary an effect on the traffic conscience of the public as the sable reminders of Death and Disaster on the roads, that look mournfully down on us from every hoarding.

Mr. W. H. Ansell

Architecture

WHAT has traffic to do with architecture, or architecture with traffic? Traffic is a moving subject, and the one thing that buildings should not do is to move.

I fear it is still necessary to remind ourselves that architecture is not concerned only with the visual appearance of a building. There is still a current impression that in the case of a house the interior planning has been done by the wife of the owner, in a school by the headmaster, in a hospital by the doctor and the matron. I do not underrate the part they play in their respective building schemes, for without them the schemes could not even begin. They write the programme, they state their requirements, but it is for the trained architect to show them how their own ideals can best be achieved and their needs satisfied.

Architecture is the designing and the provision of an appropriate and seemly environment for every human activity needing a space enclosure. This implies first of all that in such enclosure the particular activity shall be able to function with ease and efficiency. This cannot be secured by two-dimensional planning only, the design must be three-dimensional, even for functional efficiency. But functional efficiency is not the whole matter. A building may possibly create its own mass-form by the sheer essential of its purpose, plan and construction,

but these need the control and modelling of the trained building designer before they become aesthetically satisfying. That control and modelling does not consist in adding adornment, or what are generally accepted as architectural features, but in so disposing the essential components that the result shall contribute to the health, power and pleasure of those using the building. And, incredible though it may be, I have actually quoted Ruskin.

Architecture is a severely practical art which can only fulfil its mission when in actual building form. Fashions vary, building techniques change and expand, the requirements and demands of the public for its buildings alter with the sociological changes of the ages. Nevertheless, there are certain essential qualities in building design which are permanent and must be used as testing standards for all buildings, whether old or new, for the new London University and the tube stations as well as for the Parthenon and St. Paul's.

Some people, architects among them, find it difficult to apply to modern work the critical standards they seem able easily to use in appraising the aesthetic value of the buildings of the past.

All this is relevant to the design of the single building and the same principles apply to a group of buildings, a civic centre, a great hospital, a modern school, an industrial concern, with the added factors of the relation of one building with another, their connecting links, and one's architectural duty to one's neighbour.

It is in considering your neighbours and realising the importance of those relationships and the design of approaches and surroundings that you come into the province of town planning or civic design.

And in the world of to-day there is the clear expectation that the opportunity which the bombing of so many towns has created for replanning and rebuilding must result in towns and buildings which shall allow and encourage a fuller, more interesting, healthier and generally better life for all the people. The towns and villages are to be means to that end, not ends in themselves.

The kind of life is perhaps not very clearly defined in many people's minds. The average man wants a job which will give him a reasonable livelihood, a sufficient leisure and some interest in the doing of the job. He wants a labour-saving house for his family, and good schools for his children, all placed not too far from his work, and with quick, cheap and comfortable transport from one to the other. He wants most of the things indeed which men in all ages have wanted, including peace in their time and security in their old age, but he wants them in his time and in his fashion. He is expecting, or should we say hoping, that this new world will have removed much of the ugliness and waste of the old, the slums, the black smokiness of towns, and will in time give him the beauty of a spacious orderliness of which the war has so often deprived him. And curiously enough, he thinks that the architects are the people who will either give it or withhold it from him so far as the visual aspect of his towns is concerned. How far this is true remains to be seen.

During the war there was much time spent in the preparation of plans of every kind for the post-war world in general, and London in particular. Scientific, engineering, town-planning, and architectural institutions gave lectures and held exhibitions. Of the making of books there was no end. Some people thought it all premature, but it had its effect on the Government, and planners and the public, and every published report on the replanning of our great towns, London, Manchester, Plymouth, Hull, shows that the planning for convenience has obviously been influenced by consideration of the visual effect. It is accepted by all the planners that their planning of new towns or replanning of old ones must not only work well but look well.

There are dangers in planning consciously for architectural effect, though we should not forget that some of the most admired examples of past town planning bore this strongly in mind. The crescents of Bath were not built because there happened to be a nice curved road there, nor the squares of Bloomsbury laid out as the result of there being rectangular enclosures in existence which demanded houses round them.

Let us consider for a moment the relationship of roads and buildings. A building is an arrangement of compartments and their communications, corridors on the horizontal plane, staircases and lifts on the vertical. A town, too, is an arrangement of places and the means of access to them. The places are dwelling places, work places, or play places, and their means of access are roads and streets. In the beginning, was the first building set down beside a road which happened to be there, or was the road gradually formed by continual traffic to the building? Without buildings, most urban roads would not be required; without roads, buildings would be unapproachable and to a large extent unusable.

As in a building, the corridors, in giving easy access and perfect communication, must not take up so much space that there is no room for the compartments, so in a town, the roads must leave the right size and shape

for the building areas for complete efficiency. In fact, wherever buildings are projected, their planning with reference to the roads should be a part of the town-planning scheme. Too often, roads have been thought of as traffic conduits which are allowed to be lined by buildings—traffic requirements solely dictated their lines and little or no consideration was given to the shapes and sizes of the sites left between them. There are buildings in London so narrow that they barely justify the cost of their external walls.

The town should be conceived as a logical composition of buildings for defined activities, combined with open spaces, and the roads should serve the needs of the town in an efficient and dignified way.

That is perhaps an elementary statement; but how are the traffic needs to be computed? It is useless taking the superficial course of counting the number of vehicles at a peak hour on a given road and widening the road to fit. The problem nowadays is tackled much further back than that. The investigation as to the character of traffic, where it comes from, where it is going, and why it is where it is, is not an architectural matter, nor even an engineering one, but the solution affects both.

An altered location of badly sited industry might result in the volume of traffic being so reduced that no road widening is necessary. The Bressey report of 1938, even though some of its recommendations may now be questioned, did approach the problem of traffic congestion in the right way by exploring origins.

The positions of railway termini and great central markets like Billingsgate and Covent Garden profoundly affect the volume of traffic in all the roads leading to and round them.

A decision as to the permanency of the present position of such factors must be taken before a final judgment can be made as to the width and lines of roads, or any planned lay-out of their existing areas made.

But when decisions have been made, architecture, road engineering and all other interests must combine for the perfect solution.

The problems in London are vastly different from those involved, say, in the planning of a new satellite town.

London is not an efficient city in the disposal of its traffic—that I need not stress—the hold-up at Westminster a week or two ago is proof of that if any were needed.

But in attempting to cure the ill, the planning authorities have by no means a free hand. Many factors which make London what it is are permanent—I know there was one bold person who advocated taking the river across the loop in a shortened line and filling in the existing course from Westminster to London Bridge—but the river remains and is likely to remain.

There are buildings to be preserved, though some people appear to wish to reduce these as much as possible. I remember an amusing drawing in a London daily five or six years ago showing complete demolition of everything between Westminster Abbey and the City except Somerset House, and London resolved into a series of cold slabs of upright tower buildings set in windy gardens, and this was called ' a way of building from a good modern plan for democratic people.'

Generally, however, sensible people, whether democratic or otherwise, agree on the buildings the preservation of which is paramount and incumbent on any scheme of traffic improvement. One only wishes there were far more buildings in inner and outer London worth preserving. The pleasant squares of the Inns of Court, now so grievously shattered, the City Churches, the terraces which remind us of a more elegant and leisurely age than ours, even if altered to comply with modern needs, should remain wherever possible visually complete as a testimony to our grandchildren of the London that used to be.

There is, too, complete agreement that where bombing has opened up views of St. Paul's Cathedral that had better never have been closed, views that now have given pleasure to thousands, they shall to a great extent be preserved, and traffic problems met in some other way than by reclosing them. In every plan, official or unofficial, prepared for the City of London, the importance of preserving space about its great Cathedral has been recognised.

Preservation, however, need not extend to our ancestors' errors, nor to obsolete and inefficient systems of what are called ' services.'

Many local sewers, electric and gas mains, water mains, underground telephones, are woefully out of date.

Are we then to plan to utilise these with all their inconveniences, even to the point of cramping and fettering a long-term plan?

There are, we know, some underground factors like the great main sewer conduits, which must perhaps be allowed to influence planning because the chaos resulting from altering or scrapping them would be more than London could bear.

But I suggest that there are few desirable alterations in London's plan which could not be carried out without seriously affecting such things, and that neither the London County plan nor the City plan should be

unduly compromised because of the difficulties of underground engineering. The lay-outs of Kingsway and Aldwych were not made without difficulty, nor London's tubes built easily.

Is it not reasonable that the investigation proposed for the traffic above ground should also be applied to the underground traffic of the sewers, that a long-term plan for the improvement of roads and building sites shall be accompanied by a long-term plan for the improvement of sewers? A really desirable long-term plan should not be vetoed in a manner now familiar in other relationships by an insistence that no alteration in London's underground services is possible. The inner circle of the Metropolitan and District Railways was probably condemned as an impossible interference with London's sewers and gas mains. The complexity of these has vastly increased since those days, but so has engineering skill and experience.

A balance will have to be struck. Costly and difficult improvements to London's sewers should not be ruled out because they are costly and difficult, but only if the balance is heavily weighted against them.

The railway viaducts of South London are another example of the, what seemed to our ancestors, reasonable expedients for travel that have long outlived their desirability, though not their usefulness. London has paid a big price in loss of amenity for these.

A year or two ago, those who pleaded for a long-term plan involving their removal were classed as unpractical idealists, yet now the Joint Committee has produced suggestions for the improvement of London's railway systems and termini placing, that for boldness and vision go far beyond the tentative efforts of the earlier planners.

Preservation of the good, and mere elimination of the definitely undesirable will not necessarily lead to the contribution of some positive addition to London's convenience and beauty.

In the last century, and most of this, our positive contribution consisted of some inner improvements and miles of suburban streets, the London sprawl, the dreariness of which has been vastly increased by the bombing.

With such an opportuntity as is now before us, this age should certainly be able to make a major positive contribution to London of equal importance to that of Wren and half a dozen or so others in the century following the Great Fire.

It will not depend, as that did, so entirely on the personal and individual designer, but will be a more complex and co-operative affair. When a general scheme for London's development and tidying up has been prepared, when some idea of the character and volume of traffic has been obtained and suggestions made for dealing with it, such as by ring roads for segregated fast traffic, then every part of the plan should be influenced not only by traffic considerations but also by architectural ones.

This seems to have been accepted by the Planning Authorities, since Abercrombie and Forshaw have prepared the County of London Plan, and Holford and Holden are working on the City Plan. So far so good, for one can be sure that while architectural considerations will not dominate the plan, they will, with those of traffic, be fully taken into account.

May I mention a point on which traffic and architecture have often seemed at variance.

The curves of a pavement line at a bend or a crossing, while being admirable for the easy turning of a car or a bus, are not necessarily the best lines for the building frontages at that particular point. Yet there is often so little area left for building that the architect is compelled to follow the curb line in a parallel at the back of the pavement. At roundabouts and crossings it is often far better that buildings should be designed to be quite independent of the curb line, giving wider and varied pavement areas and good planning will, I think, remember this from the beginning.

The scale and size of our buildings will, in all probability, be increased, particularly where large areas have been destroyed. There are still many narrow streets with buildings no more than eighteen feet in width of frontage. The buildings have a wasteful amount of space in party walls, staircases, and separate services of all kinds. Even in commercial areas there remain many office blocks which in their plan recall the days when men had their shop or office on the ground floor and lived with their families in the rooms over. The result to-day is an appalling amount of congestion in the narrow streets and bad lighting, almost slum conditions, in the offices themselves. Both traffic and architecture would be improved by some pooling of sites which would reduce the number of streets and increase their width, while giving greater superficial area to the buildings. Some of these, if the sites were adequate, could be so planned that the street frontages were not the highest parts of the buildings while interiors consist of deep, badly lighted open wells, but that the street frontages were kept to a modest height and the interiors raised in graduated series until the centre of the block became the highest of all.

The street itself would become less canyon-like and every part of the building be better lighted and more valuable. An occasional building might have a higher

portion next the street punctuating the rhythm and relieving monotony.

Pavements for pedestrians might be arranged within the building area, either on the ground level or above, like the rows at Chester, and parking facilities provided, together with loading spaces, inside its perimeter. Congestion would be lessened and time saved.

Though much may be done in partial mitigation of present traffic conditions by traffic lights, one-way streets, parking regulations and police control, it is to architectural planning, the right planning of the spaces allotted to this very active activity, by whomsoever the planning may be done, that we must look for the complete solution of the problem. To do more than merely solve the traffic problem, to make the positive contribution to the delight, usefulness and beauty of London to which I have alluded earlier, the spaces for buildings left between the roads must be thought about at the same time as the roads and not left until everything else has been settled.

The trouble is, of course, that the motor car has grown faster than the road systems have been changed to cope with it. Restrictions alone will never do what is required to cure congestion on our roads. The multiplication of signs, even now, is a weariness to the poor motorist.

It is fashionable to sneer at vistas, or even to get angry about them, to talk about planning for pictures and so on, yet as we may hope that London will in future get some buildings of the highest architectural quality, is it unreasonable to ask that they may be allowed to be seen and even that our roads and building sites may be so disposed as to encourage the fine building which the greatness and importance of London deserve ?

Second Session

Mr. A. J. Lyddon, C.B.E.

Roads

1. Introduction

Within the limits of these few notes it is only possible to dwell on a few of the salient features which are regarded as fundamental to the relationship of roads to London Traffic and the three plans which have emerged during the last three years.

The comprehensive London Plan can be said to comprise :—

1. The L.C.C. Plan of 1943, by Sir P. Abercrombie and J. H. Forshaw.
2. The Greater London Plan of 1944, by Sir P. Abercrombie.
3. City of London Plan of 1946, by Messrs. Holden and Holford.

It is also necessary to refer to the Highway Development Survey of 1937, by Sir Charles Bressey and Sir Edwin Lutyens, which dealt almost exclusively with the future evolution of roads in and around London.

If these plans are viewed as part of a comprehensive whole they present a complete picture of the character and disposition of road development for the metropolis over the next half-century.

An area of at least 1,800 square miles is thus circumscribed within these Plans having a radius of 25 to 30 miles from Charing Cross and a population—in 1935—of 9½ million. Forecasts of future increases in population vary, but it is generally conceded that while the future population of the whole country may not show a large percentage increase, the density of vehicles per mile of road is sure to become progressively greater within the next two decades.

With this in mind it is desirable to enquire whether the traffic capacity of the roads in the metropolis has kept pace, or is likely to keep pace, with the increasing demands made upon them and to what extent must greater facilities be provided to cope with the increased number of vehicles which the travel habit of Londoners will demand.

2. Essentials of an Efficient Road Plan

A well conceived Road Plan should be based on the following considerations :—

1. The estimated volume, character and distribution of the traffic that will use the roads.
2. The safe and convenient movement of all classes of traffic.
3. The proper relation of the Road Plan to the whole transport system.
4. The practicability of the individual proposals from the engineering and cost aspect.

No road plan can be regarded as satisfactory unless it has full regard to the safety of all road users. That proper provision must be made for public service vehicles is fundamental to any road plan, and the livelihood and convenience of the citizens of London and Greater London must be regarded as essential to any London Plan.

These requirements relate not only to homes and places of work, but to railway termini, to shopping and recreational areas. Public service vehicles make special demands on the design of the road system and affect the functions to be assigned to individual roads to be used by them. In this it is

necessary that the London Passenger Transport Board should play a conspicuous part in the lay-out of the plan.

The 1943 Plan assumes that through traffic constitutes a substantial proportion of the total traffic of London and that this class of traffic is largely responsible for the congestion which now exists. It may be that the extent of through traffic in London and its effect upon London traffic problems are overestimated where ' through ' means passengers and goods whose origin and destination be outside the London traffic area.

This points to the need for a census of traffic over the whole metropolis on a basis of origin and destination as a framework on which to justify the consummation of the plan. Without some such data it seems difficult to assign any proper function to a proposed new road or to justify an expensive improvement.

For example, paragraph 157 refers to the segregation of fast long distance traffic and in paragraph 11 to Oxford Street as a nondescript traffic street and as, perhaps, the clearest example of the mix-up of through, stopping and pedestrian traffic.

A proper census of traffic in Oxford Street might well show that only a small part of it is through and that a substantial part consists of omnibuses which—though on relatively long journeys—cannot be regarded as other than traffic local to each stage of their route.

An appreciation of the fact that London traffic is preponderatingly local to London will have a material bearing on the road plan and the individual proposals which constitute it.

3. Need for Census of Origin and Destination of Traffic

In America it is almost common practice for highway development projects to be based on a survey and census of road traffic in which the origin and destination of each vehicle is determined.

Most of the road schemes and proposals embodied in the Plans justify the establishment of an Origin and Destination Census as a condition precedent to their execution. Apart from the census taken outside populous centres by highway authorities we know little about traffic trends in urban areas. The excellent bi-annual Police census taken at about 100 special situations in London is the only available data which might help a planner to obtain definitive knowledge to justify the building of a new road, or the widening of an existing one, and the data thus compiled is limited to numbers of vehicles only.

Such a census as is advocated would be costly and would cover a considerable period, but in relation to the heavy expenditure—for roads alone—envisaged in the Plans, the cost would be infinitesimal.

It is interesting to note in this connection the valuable information collected by Sir Charles Bressey of Traffic Delays on four routes, which gave authentic particulars not only of the speed normally attainable at various times of the day upon important traffic routes, but also, of the extent of the delay occurring at different points where traffic was held up.

Three routes of approximately 12½ miles were selected and a fourth of 22¾ miles, the former comprising a West-East route, a North-South route and a North-West—South-East route respectively, while the fourth followed the North Circular road.

The first three were selected to pass through the heart of London with its busiest traffic, and the North Circular route was chosen in order to avoid the centre by way of contrast.

The numerous journeys made on the cross London routes indicated an average speed of 12½ miles per hour, while the corresponding figure for the North Circular road was almost double—thus Sir Charles Bressey's investigations showed that a vehicle driver could expect to make the entire northern circuit of London, of 23 miles, in less time than in traversing the shorter but congested route of 12½ miles.

In connection with the Highway Development Survey a ' Dock Traffic Distribution Census ' was conducted on an ' Origin and Destination ' basis—this, the first of its kind, together with the example referred to in the foregoing paragraphs, are examples of the essential data which it is necessary to acquire as a background to efficient road planning, and the author desires to emphasise the necessity of regarding such a census as a *sine qua non.*

4. Factors which Determine the Length of Time it takes to Complete a Road Scheme

Whether the proposal is to construct a new road or to improve an old one, there are a number of factors which determine the length of time it takes to complete a scheme. It took nearly 20 years to construct Western Avenue—the improved north-western exit from London—which is less than 10 miles in length. That this was not the actual constructional period will be obvious to even the layman. The law relating to property acquisition, the necessity for public enquiries, notices to treat for land acquisition, various legal processes and occasional arbitration,

all affect the progress of execution. It is not infrequently thought necessary to acquire all the land necessary for the construction of a road before any constructional work is permitted to commence, and it is not possible to acquire compulsorily land in excess of that necessary for the actual site of the road.

It is necessary, therefore, that we should appreciate some of the causes which make for delay in the carrying out of road works if we are to estimate the degree of probability which may attach to some of the more nebulous proposals adumbrated in the Plans within the next two or three decades.

When the London Arterial Roads were constructed after the 1914–18 war, to give employment to London labour, it was made possible to enter on the land required after the expiration of 14 days' notice to the owner and occupier. While this will not be practicable where property, as distinct from land, has to be acquired, it is thought that there is much to be said for a reversion to the provisions of the Public Works Facilities Act of 1920 in this connection.

5. Highway Development Survey, 1937

It is of interest to note that nearly all the road proposals contained in the L.C.C. Plan of 1943 are contained in Sir Charles Bressey's report of 1937. Many of them have been approved in principle by both the L.C.C. and the appropriate Government Departments.

The general study of traffic needs contained in Sir Charles Bressey's report of 1937 contains a most comprehensive list of important road improvements, either by way of widenings or new construction, the execution of which will go a long way to relieve much of the traffic congestion which will again become acute when greater vehicular movement becomes possible.

Some of the schemes which are set out hereunder are old in conception and some of them have been partly executed, but all should be regarded as of first priority for early execution, as they have been regarded in all plans for the amelioration of London traffic evolved in the last two decades, of primary importance.

East and West Connection

A proposal to form a line between Eastern and Western Avenues has been accepted as essential and might well start with a continuation westwards of radial road No. 11 and follow a part of ring road 'A' and be completed by an improved connection with Western Avenue (radial road No. 2).

South Circular Road

Ring road 'C' partly follows the established route of this road and with proper connections to radial road No. 1 on the west and with radial road No. 15 on the east, this should form an essential east-west connection on the south of the river.

Approaches from the North to the Dock Area

Proposals for improvement of these approaches formed an important part of the Bressey Report and are embodied in the Plan with some modifications.

Elephant and Castle

War demolition in this area makes it possible to effect a roundabout scheme here of the two level variety. This should make for greater freedom of traffic movement at this pre-war congested junction.

Cromwell Road Extension

This scheme has been partly executed, and its completion, terminating at the eastern end of the Great West Road, with fly-over junction, will relieve the slow movement of traffic at Hammersmith to a marked degree.

The foregoing are only a few of the schemes which have either been accepted in principle, or have been partly executed. Such proposals as :—

(*a*) Duplication of Blackwall Tunnel and improving the North and South approaches.
(*b*) Completion of the Dartford-Purfleet Tunnel.
(*c*) Improvement to the South approach to Wandsworth Bridge.
(*d*) Widening Park Lane.
(*e*) Widening Notting Hill Gate,

together with a number of others which have been advocated and in many cases accepted, are all worthy of early execution to form part of the general desire to afford greater freedom of traffic movement.

What must be regarded as long-term proposal, such as the construction of ring roads and new radial roads, are all essential parts of the Plan, but there are so many schemes which have passed the preparatory stages that a real and early contribution to London traffic problems can be made by a concentration on their execution without in any way marring the conception of the Plan adumbrated by the L.C.C. in the 1943 Report.

6. London County Council Plan, 1943

Sir Patrick Abercrombie and Mr. Forshaw, in their report to the L.C.C. in 1945, said in relation to roads of the metropolis :—

' The need for improved facilities in and around London has become so acute that unless drastic measures are taken to relieve a large number of the thoroughfares, crossings and junctions of their present congestion, there will be a grave danger that the whole traffic system will, before long, be slowed down to an intolerable degree.'

The war has, of course, prevented the execution of any schemes of amelioration, but some of the unfortunate results of the ' blitz ' can happily be made profitable from a road improvement standpoint by providing facilities for road widening, or new construction, which might well expedite the execution of some of them. For example, the demolitions in the neighbourhood of the Elephant and Castle make it possible to plan a roundabout system there on a scale which under pre-war conditions would not have been possible. An island site with vehicular traffic on one level and all other traffic on a different level would effect a great and much needed improvement at this important road junction.

The chief road interest in this 1943 Plan centres in the proposal to form ring roads A, B and C, with the twelve radial roads forming the principal means of ingress and egress from London.

Ring Roads

It is perhaps in the function propounded for the ring road B that an element of controversy may be said to arise. The provision of a ring road so located that it will relieve congestion in the central area, as defined in paragraph 74 of the Plan, is to be regarded as fundamental provided its function will be to deflect traffic from and drain traffic out of the area without creating an impediment to traffic passing the central area and the outer area.

The plan, however, assigns this function to the wider flung ring road B, which it is suggested, is too far from the centre to fulfil the purpose of relieving congestion and promoting freer circulation of traffic in central London.

It is thought that it would be better to design ring road A to provide for free flow to the greatest extent practicable in the approximate location given to it by forming various sections of it at other than ground level, some sections being sub-surface, in tunnel or elevated, according to circumstances, except where physical or other conditions preclude a particular type of construction.

If the relative functions of ring road A and B are thus interchanged, the character and design of ring road B would not be uniform, but could be governed by the differing traffic value of its components, which take the form of existing roads of varying traffic values and which are proposed to be widened and remain at ground level on their present alignments.

To the argument that the ring road A construction, as suggested, would form a barrier to the free flow of traffic it is necessary to postulate that when constructed at different levels this would not only not be a barrier, but because of its smaller periphery compared to ring road B, would provide an incentive to circulatory traffic and furnish a much needed road connection with most of the terminal railway stations.

Ring road C has been partly conceived and achieved by the partial construction of the North Circular Road and needs little comment beyond the need for its early consummation.

Radial Roads

The conception of a series of ring roads would be incomplete without the inclusion of a radial road system. These exist in the twelve principal approach roads to the metropolis numbered consecutively on the Plan.

Coincident with the construction of ring road A, as suggested, it is necessary to envisage the replacement of existing sections of radial roads by new lengths of road conforming in design to that outlined for ring road A. This is necessary because of the difficulty of redeveloping or even widening, existing roads in areas which are already fully developed and which it will not be possible to redevelop over a long period of years.

If it is accepted that between ring road A and B, the existing length of radial roads should be replaced by alternative lengths of new road conforming to the revised standard and design of ring road A, it would generally be possible to improve by widening or dualling the carriageways of most of the remainder of the radial roads—Whitechapel Road is a case in point, where the present width between buildings makes it possible to introduce dual carriageways of adequate width and thus facilitate traffic movement coupled with increased safety.

Cross Routes

The proposal to construct East and West routes Y—Y and X—X partly in tunnel, is to some extent governed by the acceptances of the alternative rôle assigned to ring road A.

If ring road A be built at other than ground level, to accord with the conditions of the area through which it passes, it will not be found to act as a barrier to traffic within and without the area it circumscribes, but will form an avenue for traffic movement of a circulatory character rendering less necessary the construction of the proposed cross routes X—X and Y—Y, which are to a large extent essential to the development of ring road B, as conceived by the authors of the 1943 Plan.

Nothing has been said in the foregoing about the advantages which accrue and the necessity for constructing facilities for the passage of conflicting lines of traffic at different levels. Bridges, fly-over junctions, roundabouts, etc., all have their advantages and are essential to the consummation of efficient planning for traffic movement. Needless to say their execution in developed areas is limited, not only by the area they occupy, but by the heavy cost involved in relation to their traffic efficiency.

7. Greater London Plan, 1944

The Greater London Plan can be said to be framed on the London Plan of 1943 in association with the Highway Development Survey of 1937 (Bressey Report). In this it follows that the main road pattern forming the basis of both the 1937 and 1943 proposals needs to be followed in the Greater London scheme.

The existing radial roads, which in the main, terminate at ring road A, are to be superseded by the construction of new 'express arterial roads,' which would supersede the existing roads. To some extent the construction of these new roads follows the scheme of the County Surveyors' Society for the construction of motor roads throughout the country. An additional ring road D is proposed following a line approximately 13 miles radius from Charing Cross and outside the proposed area of Green Belt.

There are thus four distinct ring roads proposed, only one of which follows existing road alignments, viz., ring road C, which approximates to the North and South circular roads.

The interpolation of ring road D, following the approximate location of the North Orbital Road, as an express arterial road, may have doubtful value until it can be established that such a road would really function in a manner to justify its construction, that is, to induce traffic to circulate round the metropolis at a distance of 30 miles from its centre, and only an origin and destination census can confirm or otherwise the justification for such an express arterial road.

8. City of London Plan, 1946

In many respects the Report of Messrs. Holden and Holford for the City, can be regarded as forming a part of the larger conception for metropolis planning.

In some of the blitzed parts of the city opportunities occur to close small and narrow streets and to erect buildings over larger sites than heretofore, thus providing adequate space for highway widenings. That the majority of road proposals of the City Plan must be in the form of road widenings, is obvious. It is suggested that the erection of buildings of a character which will take the form of grouping of large structures of the office type, should be encouraged, thus liberating adequate space for wider roads commensurate with the buildings abutting on them. Limitation of space does not permit more detailed observations on the City Plan 1946 which, in conception and detail, has been much improved since the original scheme was adumbrated.

9. Collaboration of Planners, Police and Engineers Necessary to Evoke Road Plans

In the opinion of the author, the consummation of any Road Plan, and in particular that of London, can only be achieved by the collaboration of the Planners, the Police and the Engineers. It is necessary that the planners, should present their ideal based on the needs of the future generation, while the Police experts should bring their experience to bear upon the likelihood of traffic moving freely and safely in accord with the Planners' ideals.

The association of Planners and Police would be incomplete, however, without the co-operation of the Engineers, whose advice on the possibilities of construction and the probabilities of cost, are indispensable conditions to the execution of any Road Plan. In the hands of such triumvirate any plan would emerge free from the taint of impractical idealism.

V. A. M. Robertson, C.B.E., M.C.

The Railways as Affected by the Replanning of London

The primary object of this conference is, I believe, to renew interest in the problems arising from the replanning of London, and also to produce useful discussion and an exchange of views which it is hoped will prove of considerable assistance in the initial solution of these problems.

The time placed at my disposal does not permit of very much opportunity to bring out to the full the technical problem of the

Railways in London in relation to the Plan for London. I propose, therefore, to raise matters of a general character in some detail and only to devote approximately a third of the paper to pure Civil Engineering.

May I at the outset make it quite clear that I speak to-day as an individual and not as the Chief Civil Engineer of the Southern Railway Company. The views expressed in this paper are my own and are not in any way influenced by any railway policy, plan or programme.

In dealing with this extremely difficult question of the railways I assume that the majority of those attending this Conference to-day have read, or have knowledge of, the various reports on the replanning of London. These reports, as was expected, contained proposals which affect the railways to a very large extent, and which if carried out would involve works of very great magnitude, involving years of study and planning at costs which even in these days of high prices would be stupendous.

I would not suggest that because of these factors the railways should be left alone and the new London planned round them, as this would obviously prevent proper planning and due regard being given to the future. I would be the first to agree that the replanning of any city, particularly London, must of necessity embrace all the associated problems, including transport. It is obvious that many improvements to our railway facilities are long overdue, and I would not exclude the much criticised viaducts from these improvements.

The planning of London involves consideration of three major aspects :—

First—the *people* who live, work and have their recreation within Greater London ;
Second—the *metropolis* as a great commercial centre and the seat of the Government ; and
Third—*transport* as the means of moving people and goods from one point to another within Greater London or to and from London.

The London planners who have spent a great deal of time in the preparation of their reports and recommendations have not hesitated to suggest drastic action with some of the London termini and the river bridges and viaduct approaches thereto. There are, in my view, some perfectly sound reasons for these recommendations, which, if given effect to, would provide pleasanter amenities for the citizen, an opportunity to remove some of the existing road traffic congestion which is bound to get worse, and the possibility of making provision in some instances of improved railway facilities to the points of maximum concentration of work. To be precise in this respect, some of the proposals of a specific nature included in the various planning reports to which I have made reference include :—

First—the electrification of all lines leading into London from suitable interchange points ;
Second—the separation of Main Line and Suburban traffic ;
Third—the rebuilding of London Bridge, Waterloo and Fenchurch Street Stations and improvements to Euston and St. Pancras as one station, and to King's Cross, Paddington and Liverpool Street ;
Fourth—the rebuilding of some terminal stations at two levels, with provision of flat roofs for air landing.

In addition various other railway proposals are made, including the construction of new deep level lines north and south of the river, and a suburban passenger route passing below some of the terminal stations of the Great Western Railway, London Midland and Scottish, and London and North Eastern lines with interchange facilities to their termini.

One of the planning reports recommends as of first importance in the scheme for replanning London the removal of the railway viaducts and bridges over the river serving four Southern Railway Stations, viz., Charing Cross, Cannon Street, Holborn Viaduct and Blackfriars. In view of my somewhat intimate association with these stations from 1911 to 1919 and since 1943 I would like to take one station and give you my personal views on the problem. I think, perhaps, Charing Cross is the most suitable to consider because of the controversy which has existed for many years on the question of its retention or removal. It is well in this connection to remember that the following bodies have already studied and made recommendations concerning it :—

1. A Select Committee of the House of Commons in 1930.
2. A L.C.C. Advisory Committee (or the Scott Committee) in 1931.
3. London and Home Counties Traffic Advisory Committee in 1936 and again in 1938.

Any plan to remove or rebuild Charing Cross Station either below or above ground must be related to an approved plan for the improvement of roads in the Strand, Trafalgar Square, Whitehall and Charing Cross Road area, and similarly must be related to the existing and any proposed Underground Railways in the immediate vicinity.

The size and layout of a new Charing Cross suburban station built below ground

would depend on whether the station is to be a terminus or on a new line of route proceeding north of the river.

It is important to appreciate at this point the measure of passenger traffic handled at Charing Cross Station on the Southern Railway, and the following figures are, therefore, quoted. They represent a weekday in February, 1938.

ARRIVALS	Passengers
During 24 hours . . .	56,090
Between 7.0 and 10 A.M. . .	37,095
Heaviest hour of arrival . .	17,034
DEPARTURES	
During 24 hours . . .	58,015
Between 4.0 and 8.0 P.M. . .	37,257
Heaviest hour of departure .	15,534

If the measure of passenger traffic at the four stations referred to earlier, viz., Charing Cross, Cannon Street, Holborn Viaduct and Blackfriars, are similarly considered then the figures for these stations during the same weekday in 1938 show that at these four stations alone 1,742 trains carrying 270,000 passengers were dealt with in 24 hours.

I could complicate the issue still further by adding figures for London Bridge station, and then adding a percentage to the grand total to provide for an average day during the holiday period in August in order to arrive at a maximum. These further figures, however, do not matter much, as it is obvious that the proposal to remove the existing viaducts and bridges leading to these four stations and, therefore, the stations themselves, immediately produces a passenger handling problem of the greatest possible importance.

Despite these difficulties I personally do not disfavour very serious consideration being given to the removal of the bridges and viaducts and the stations themselves as suggested by the planners, provided that adequate alternative arrangements are clearly defined. These arrangements must provide for the handling of passengers in excess of those carried in 1938, and must provide for the complex problem of dealing with passengers' luggage, parcels, mails and other similar problems arising from the facilities afforded to the travelling public by the Main Line Railways, and which are not as yet provided by the L.P.T.B. on their underground trains. This is a most important point which I feel the early planners may not have quite appreciated.

The alternative would be to educate the public to travel luggage free and to refuse the carriage of parcels and mails, etc., on these services, with possible reaction on others or on street traffic. I cannot imagine that such a scheme would be welcome or even partly acceptable in any quarter.

It has been said that a brick should not be laid nor a yard of concrete mixed in connection with the rebuilding of London to a new plan until the full scheme has been designed in detail and approved by all interested parties and undertakings. I would go further, and say that nothing should be done at all until it can be definitely proved by competent people that if the removal of bridges, viaducts and stations does form part of the approved plan then these removals and the consequent effect on railway traffic must be safeguarded without any shadow of doubt by additional and adequate Underground Railways provided with stations designed and built to take care of the anticipated future traffic needs. I will not deal in any detail with the question of design of such Underground stations, as I am sure my friend, Mr. J. C. Martin, will cover this point in his paper.

If such a guarantee cannot be given, then the London Plan, however carefully considered, however beneficial it may be for the citizen in his home, at his place of work or at his recreation or his leisure, is doomed to complete and utter failure. The railways are vital to London and their retention in some form or another in the plan is obvious beyond dispute.

The removal without adequate replacement of the Southern Railway Terminal Stations which exist north of the river to-day would deprive London of railway facilities which for years have enabled hundreds of thousands to travel conveniently to points nearest to their places of work. No rebuilding of London should, in my view, remove these facilities without providing suitable substitutes. If these are not possible then the stations should remain as they are.

May I now put forward some very general points in the hope that they may be discussed.

I would electrify all railways within the Greater London area, and if need be adopt the American practice of changing locomotives at some point outside the County boundary.

I would, where practicable, divorce suburban traffic from main line traffic, and where possible place the former below ground level in tunnels of a suitable diameter to accommodate main line rolling stock. This would entail the construction of tunnels 17 feet in diameter. I would provide express underground lines where such can be justified on the score of passenger requirements. I would connect the main line terminal stations with an Underground Line, and arrange it so that the public enjoyed a selection of stations to suit centres of business,

shopping or places of amusement. I would, where working permitted, consider the removal of all railway goods depots to definite and carefully selected centres for the purpose, and I would build roads to these centres upon which only commercial and goods vehicles would be permitted to operate at certain times of the day and night. At other times I would permit normal traffic use of these roads.

I would aim at banning to the heavily used roads of London all slow moving horse-drawn traffic. I would provide plenty of underground car parks and garages. I would endeavour to meet the traffic peaks by staggering hours of work, hours of shopping, and hours of commercial vehicle movement in the streets. Just how all these dreams could be brought to fruition is a matter which obviously would take a young army of skilled planners and engineers many years to thoroughly investigate and design, but I feel that solutions to the large majority of the points raised are possible if the planners, the merchants, the transport undertakings and everyone combined. I do not forget that the subsoil of London to a depth of 50 feet below the surface is well riddled with underground railways, the Post Office tube, and public services, and I do not forget that in many places below ground level one meets subsoil conditions through which building operations and the construction of underground railways are enormously costly and difficult.

The replanning of London will obviously cost many hundreds of millions in sterling and will occupy four or five decades or more to carry out, but those of us who are privileged to be associated with any planning in London to-day should not be thwarted by these apparent difficulties. Let a prompt start be made on the vast amount of planning investigation and design which is essential. Let the government take the lead in getting down to the problem.

As an engineer with forty years' experience of London, of London railways both above and below ground, of the growth of industry in the City and of the traffic in its streets, I would give, if and when required, my closest co-operation and assistance in the preparation of a properly designed and co-ordinated plan. I am not sufficiently experienced to indicate just what legislature would be necessary to achieve an ultimate beneficial and concerted scheme which would be carried out to a predetermined programme, nor do I yet know how such a scheme would be financed, but I am quite convinced that as parts of London must be rebuilt, that as the road traffic problem must be re-tackled, that as living conditions must be vastly improved, so should the railways be linked and modernised to a plan, and all these things should be fitted together in the great combined effort of producing a better London in which to live and work and from which the affairs of our country and commonwealth can be properly guided.

As yet I have only dealt with the general problems which confront the planners, and I hope, have shown that it is not sufficient to indicate on a small scale plan of London that this stretch of railway or that terminal station should be abolished and that the railway traffic thus unprovided for should be taken care of by an underground link here or a diverging express line there. I can assure the planners that until they possess the full engineering facts, the existing traffics with peak hour details, and the number of trains which are considered essential in future, they will be groping in the dark. It is said in some of the planning reports that the railway proposals still require working out in detail, and this is very true, as I shall now try to prove.

From figures in my possession I can state that on a summer weekday in 1939, 91 trains arrived at London Bridge, Cannon Street, Charing Cross and Holborn Viaduct terminals between 8.30 *and* 9.30 A.M. and a similar number of trains left those stations on the same day between 6.0 *and* 7.0 P.M.

Assuming the capacity of a tube railway to be in the region of 30 trains per hour on one track, and having due regard to the special requirements of a main line railway, operating long suburban trains, it may be necessary to provide at the very least eight tube tunnels (four up and four down tunnels) between the Surrey Canal and London Bridge, and four tube tunnels (two up and two down) to form the circular route suggested in one of the plans. The planners also have in mind projecting certain suburban services (at present being accommodated at Victoria Station) over the proposed circular underground route. The plan provides for the electrification of all suburban lines north of the river and their linking with the Northern Area Suburban Circuit by an underground line from Paddington to Victoria and at Whitechapel.

These with the projection of additional services over the proposed loop at Cannon Street from the Northern Area and at Charing Cross from the Battersea direction presupposes such a complicated track lay-out that without a detailed study no accurate opinion can be formed as to its feasibility either from a construction or operation point of view.

An approximate calculation however, reveals that 160 single track miles of new

underground tunnel might be required to replace the Southern Railway existing facilities via London Bridge to the London terminals excepting Waterloo (Main Line) and Victoria. Added to this, large diameter tunnels at the proposed stations would be essential, new rolling stock with sliding doors would be required, as also high speed lifts and escalators, etc., etc. Exceptional works require exceptional treatment and if these proposals ever develop I have no doubt they will receive such treatment, but some co-ordination of the highest priority would be essential to produce the labour and materials for such a work after they were designed.

I cannot, therefore, suggest without full details whether the proposals hold merit or whether they are practicable, but the planners will no doubt satisfy themselves and the railways that these proposals are truly possible and not only hopes in the scheme of things.

I have indicated earlier in this paper that I would generally subscribe to the view that consideration be given to the removal of Charing Cross Station and the Hungerford Railway Bridge assuming alternative provision is made for dealing with the traffic of to-morrow. If a suitable alternative is forthcoming, how can Charing Cross Station be replaced, and if it can, where should it be located and at what level? Let this problem be my technical contribution to this short paper.

There are 6 platforms at Charing Cross Southern Railway Station to-day and they deal with 700 trains in the 24 hours on an average weekday, and the numbers of passengers indicated earlier. That a station at Charing Cross to deal with Southern Railway traffic is essential I have no doubt, that this station should provide for main line expresses from and to the coast and whether it should be a terminus or on a line of underground route is a matter for consideration. It might be argued that the suggested segregation of main line from suburban traffic could take place in such a way that the long distance express trains could use Waterloo Main Line Station instead of Charing Cross.

A glance at the railway map will show that to make this provision would entail very drastic alterations to the routing of main line and coast trains now using Charing Cross, and in order to reach the existing Waterloo (Western Section) as a terminal these trains could not be routed through the existing London Bridge, an arrangement which would entirely upset the balance of traffic working to say nothing of inconvenience to the public. It would be possible, however, to restore and increase the old connection between the S.E. & C.R. and the L.S.W.R. which existed at Waterloo prior to the building of the new station. This connection would provide through running between the existing Eastern and Western Sections of the Southern Railway. Such a connection would also provide through suburban running between these two sections. As, for example, a train from the North Kent line could be routed to Epsom or Windsor.

These points are made in order to draw attention to the extreme difficulty of excluding express traffic from Charing Cross Station and diverting it into another London terminal and to the possibility of closer interrunning of suburban traffic. I personally would hesitate before destroying the present lay-out of Waterloo.

I can imagine the planners possibly suggesting that Victoria Station should be one of the two London terminals used for main line express trains to the Kent coast, so that a new Charing Cross could be built below ground to deal only with suburban traffic. Here then is one of the main problems centring round Charing Cross.

However, for the sake of argument and in order to obtain an exchange of views, shall we assume that a future Charing Cross should have 6 straight platforms, each of which must be not less than 650 feet long, that the type of traffic should be electric suburban only, and lastly that this station should be underground? The first question which arises naturally is whether such a large station can be built underground, and if so at what depth can it be constructed so as to pass under the river, avoid the existing tunnels of the Bakerloo and Northern lines and the District lines under the Embankment, and at the same time provide, if required, a physical interchange with the Underground stations at Charing Cross, Strand, and, if possible, Trafalgar Square. I have had a diagram prepared of a hypothetical station showing the shallowest depth at which I feel it could be constructed in order to meet the above requirements, and it will be seen the vertical distance from the existing level of the courtyard outside the existing station to platform level at the new underground station is approximately 120 feet. This vertical distance will entail longer escalators for passengers than any existing to-day, if the vertical rise is attempted by one escalator, and high speed lifts of very considerable depth for parcels and other similar traffic. The locality and size of Charing Cross station, whether above or below ground, prohibits, I presume, its use as a point for air landing unless possibly for helicopters, which as yet are only partly tried, and inasmuch as

good hotels are not too plentiful in the area, my suggested cross section on the screen provides for a modern hotel so constructed that the road planners are very largely free to do what they like at road level. The main floor of the hotel would be the first floor above street level and would be reached by escalator from the station.

I have not attempted to work out the full details of a scheme for an underground main line suburban station at Charing Cross, but the diagram shows a hypothetical scheme, the planning, designing and construction of which would take some years to carry out at a cost which would be approximately 17 million pounds sterling at present-day prices. The next slide is an enlargement of the hypothetical cross section showing the station tunnels and platforms.

An underground station at the depth indicated would in all probability have to be built as a series of tunnels and subsequently opened out to the fullest possible extent in order to give adequately wide platforms with the maximum number of wide openings to provide for handling the passengers carried by heavily laden suburban trains.

The type of station I have in mind is similar to Gants Hill built by the L.P.T.B. before the war on the Eastern Extension of the Central Line, or by the engineers who constructed the new Moscow Underground. The station could be double ended with escalators at the Strand and Embankment ends.

The vertical rise of 120 feet from the platforms to the street is 40 feet more than the maximum rise covered by the longest existing escalator on the L.P.T.B. to-day, and as may be remembered the largest escalator tunnel in existence to-day is 56 feet diameter containing four parallel escalators, at Holborn. I have not attempted to show escalators on the diagram but high speed luggage lifts are included. The platforms are 17 feet wide with many openings between them. The station tunnels are 30 feet internal diameter cast iron and the overall width of the station would be about 220 feet. I doubt very much whether a totally satisfactory design could be prepared of a subsurface station which in every respect would be suitable to handle the existing numbers of passengers and type of traffic which is dealt with at Charing Cross to-day. Despite modern methods of extracting heat and vitiated air, providing ventilation and fresh air free of irritating draughts, luggage lifts and parcel chutes, etc., I find it difficult to visualise at the moment how the handling of parcels, milk, fish, mails and fruit, etc., could be properly and conveniently dealt with. I am, however, definitely inclined to the view that suburban passenger traffic with the luggage normally associated with this type of traffic could be dealt with, it being remembered that the period of intensive traffic or during the morning or evening peaks the flow of traffic is normally either IN or OUT.

What exists to-day, however, does not necessarily mean that the end of progress in this type of design has been reached, but again I submit that the planners should satisfy themselves that longer and faster escalators in large diameter tunnels are practicable and that it is possible to construct an underground station of a size and to a lay-out suitable for handling passengers at a rate in excess of the capacity of the existing Charing Cross Station, with full amenities of an improved type. Whether an expenditure of the order quoted could ever be justified is a matter I would not at this stage like to conjecture, but there may be someone in the audience who is competent to speak on this point.

The reconstruction in the City of London Plan of 1944 contains certain drawings from which I gather there is obviously a desire on the part of the planners that the railway bridge at Blackfriars together with Blackfriars, Ludgate Hill and Holborn Viaduct Stations, should be removed in order to permit the realisation of the City plan. The report, however, makes no major recommendations affecting railways.

In order to reach a decision on this complex problem it would be necessary for the most careful plans to be prepared showing whether it is practicable to sink these lines below ground, which it will be appreciated involves construction at a depth below the river to avoid the existing lines of the Waterloo and City Tube and the District Line at Blackfriars and the Central Line.

These facts are, I see, fully appreciated by the planners. My only reason for making any reference to this extraordinary railway problem affecting the City is to stress the urgent necessity for thorough investigation of a civil engineering character into the possibility of putting underground all the railway lines concerned, not forgetting that these lines carry on the direct north-south route very heavy mixed passenger and goods traffic, the latter being steam operated.

As to the probable cost of putting these lines below ground it will be appreciated that without some scheme to work on figures of approximate cost might firstly be considered a mere guess. However, I have some facts which have prompted me to give a figure of approximately 17 million sterling for a new underground suburban station at

Charing Cross, and I am prepared to hazard a guess that similar work in the Blackfriars area might cost at least three times as much. This should provide underground lines depots and stations, which I am assuming the railway company might require, between the river and the widened lines at Farringdon Street.

Time prohibits further views or remarks on my part, and I would conclude by expressing the wish that during the discussions to-morrow, speakers may find the time and take the opportunity to raise points for useful consideration.[1]

Mr. E. Colston Shepherd [2]

Air Transport

THERE may be some still who doubt the need to include air line traffic in the long-term plans for ground transport systems in and near great cities. Those are the people who believe that the air lines will eventually deliver their passengers, with the help of helicopters, right in the heart of a big town. I believe those people will be proved to be wrong.

There are others who are disposed to answer the question of how to handle air line traffic by prescribing a railway link for every big airport. We have all seen the assurances in the Press that the great London airport at Heathrow can easily be linked up with the Southern Railway's line between London and Staines and that the journey need take only half an hour. The people who hold this view are not necessarily wrong, but they have still to be proved right.

There may be yet a third view which maintains that the road communications of great cities must be improved for the sake of road transport in general and that the traffic to and from the airports will be satisfactorily embraced by that improvement. Those who hold this opinion would receive more support if there were a real prospect of rapid improvements in the road systems. London is our subject; and what must determine our view of the probable adequacy of the approaches to London is the rate at which they can be made capable of carrying a largely increased flow of fast traffic.

What is the nature of the load for which provision has to be made? And how quickly can the question be expected to become acute? At present London has two main airports—one at Heathrow for the long-distance lines and the other at Northolt for the home and European lines. The Heathrow airport should be ready for full use in five years' time. It will then have three sets of runways and much improved landing aids for use in bad weather. By that time, it should be capable of landing one liner every six minutes and of sending off one liner every two and a half minutes, in poor visibility. By that time, some of the liners will certainly be carrying 80 to 100 passengers and four or five tons of freight. If, as is likely, two sets of runways can be used at the same time, the frequency in poor weather will be doubled.

At peak hours, even in bad weather, the traffic movement between Heathrow and London should be not less than 2,000 people and some 50 tons of freight an hour. A high intensity of movement will be reached before 1951. The expectation, concerning European traffic alone through the two airports that must carry it, is that there will be a daily movement of 6,000 people between those airports and London by the year 1948, and that this will have risen to 8,000 daily in 1951.

Both existing airports (Heathrow for long-distance services and Northolt for European and home services) are on the west side of London. The general belief is that there will have to be a third; and the assumption is that it will be to the south or south-east of London. Heathrow stands on the Great West Road, Northolt on Western Avenue. Heathrow is not far from the Southern Railway's Staines line and is three miles beyond the terminus of the Piccadilly (Underground) Railway at Hounslow West. Northolt is near the L.N.E.R. and G.W. line to Aylesbury and is about equally close to the Uxbridge branch of the Piccadilly line.

The question which presents itself is whether to trust to road transport solely for handling the airport traffic or to aim at railway links. If the decision is to use rail transport, should it be on the main line systems or on the Underground system? I may say at once that my own choice is for links with the Underground system. The reasons for my choice constitute the main argument of this paper and I should like to clear the ground by explaining my objections to the other possible solutions.

Let me first dispose of the popular illusion that helicopters will soon be flying like 'buses between the airports and rooftops in London. No doubt there will be helicopter services of that kind when once the helicopter has been made safer than it is to-day by the provision of an automatic change from powered rotation to autorotation in the event of engine failure; but helicopters will have an extremely limited capacity for many years

[1] The author expressed his indebtedness to Mr. V. R. Husband, of his staff, for assistance in preparing the plans from which his slides were made.

[2] Mr. Colston Shepherd was unable to attend the Conference and his communication was read by Wing-Commander Cave-Browne-Cave.

to come, and there would be dangerous congestion in the air over the West End of London if 100 or more helicopters were operating into and out of a central station every hour at the busy time of the day—especially in poor weather.

Of road transport I will only say for the present that both the Great West Road and Western Avenue come to an end at least four miles from the heart of London, the one at Chiswick and the other at Shepherd's Bush. The journey by coach between the West End and Heathrow occupies a full 45 minutes; that to Northolt occupies 40 minutes. Any notable increase in traffic congestion towards the centre will add to those times. And there is no guarantee that the western entry into London can be much improved during the next five years. On this subject I have a little more to say later.

Next we come to the question of a rail link with one of the main companies. As the Southern Railway is already electrified and as Victoria 'sounds' the right terminus for foreign travel, we may take the case of Heathrow as a fair sample. The airport will need fast trains. It will probably need frequent trains—perhaps as frequent as three an hour. Those trains will have to use a line which, between Ashford and Barnes, consists only of a double track. There can be no overtaking the slower local trains without constructing two more sets of track.

Again, if these trains are to run into Victoria (the present terminus of British Overseas Airways), they have to cross from the extreme left of the junction at Clapham to the extreme right. So big and so busy is that junction that only a fly-over could serve to carry frequent trains across to the Victoria approach. The alternative would be a separate incline to meet the up line to Victoria somewhere near Grosvenor Bridge. Either device would be likely also to demand a widening of Grosvenor Bridge to carry the extra traffic.

Doubling the tracks over a distance of six or seven miles would mean a good deal of disturbance. This and the fly-over or incline, together with difficulties concerning Grosvenor Bridge, would also involve a heavy expenditure. Heavy outlay is not to be avoided whatever course is ultimately adopted, but there should be less disturbance of existing property if the duplication of tracks were undertaken on the system of the Piccadilly line instead of on the Southern Railway.

I do not pretend that there would be no disturbance in widening the existing lines from somewhere near South Harrow (for Northolt) and from Hounslow (for Heathrow) to the junction of those two branches at Acton. Although there are at present four tracks, shared by the Piccadilly line and the District Railway between Acton and Hammersmith, I do not suggest that these would necessarily suffice for the extra traffic deriving from the two airports. I am aware that additional tunnels which would be needed east of Hammersmith must be costly.

There are special advantages in this proposal which make it worth considering even in the face of heavy expenditure. One is that the traffic of the two main airports can thus be brought together at a junction at Acton and can be brought as a single stream to Earls Court where contact can be made not only with other branches of the Underground system but also with one of the best freight-distributing points for some of the main railways. In one way or another there is rail communication between the neighbourhood of Earls Court and Willesden Junction (L.M.S.), Paddington (G.W.R.), Marylebone (L.N.E.R.), Euston (L.M.S.), King's Cross (L.N.E.R.), Liverpool Street (L.N.E.R.) and Clapham Junction (and thence the various goods depots of the S.R.).

Advantages in this respect could not be equalled by bringing the airport traffic from Heathrow into Clapham Junction and that from Northolt into Marylebone or Paddington. The new tunnels recently proposed, to give through connection between the various railways, promise to link Clapham with Charing Cross and with Baker Street. They will join Paddington also with Charing Cross and Marylebone with the Bank. They will not serve to bring airport traffic to any central point at which an airways terminal could conveniently be located.

By far the best situation for a terminal has already been proposed to the Cabinet and has been refused. This is the exhibition building at Earls Court, now earmarked for periodical trade fairs. That building would have allowed space for the offices of the operating companies, for passengers' waiting rooms and assembly halls, for the handling of mails and freight. Near it a special airways Underground station could be provided, and on the surface space is available for loading road transport. Communications between Earls Court and other parts of London by Underground railways are good. When provision has to be made for communication with a third airport south of the Thames, road transport would have an easy way out; and underground access through the City and East London does already exist and would presumably be capable of amplification at a price though without any disturbance of buildings and public services at surface levels.

When these matters are considered in

relation to the volume of traffic likely to offer in the next five years and to the prospect of further development thereafter, Earls Court does seem to be the best site for a terminal. Farther though it be from the City and the West End, it is far better served with means of communication than is the present terminal at Victoria. That terminal has served well enough in the period in which air travel was the perquisite of the wealthy and of the representatives of wealthy companies. Air transport in the future will be put at the service of a much wider section of the public, and the majority will be people who are already accustomed to arriving at their main departure terminal by public transport. To these, the Underground link is a natural and, on the whole, a favourite method of reaching the departure point.

Those who are able to go direct to the airport by car will be a minority, as they are at present. In time to come there may be more who will be willing to hire a helicopter taxi for the journey between the centre of London and the airport. Flying taxis of this kind may be available before many years have passed, possibly with landing stages on the river. But helicopters will handle only a small fraction of the traffic. The rest must go by road or rail ; and there will still be dissatisfaction if the journey of 12 to 14 miles between London and the airport occupies as long as the journey by air between the airports of London and Paris.

That part of the London Plan which deals with circular roads will help in some respects. The outer circular road at an average radius of about 12 miles from the centre will be useful for linking up the three airports. Along that road will flow the exchange traffic which must pass from one airport to another to complete its air journey. The smaller circular road around the heart of London will also give some relief to through traffic but will contribute little if anything to the planning of a service of road transport between an airways terminal in Central London and the three airports. If the operating companies are forced to rely on road transport, nothing less than a star pattern of main roads passing right through the heart of London will suffice. The alternative would be the creation of a terminal at some point outside the congested area where room could be found for a busy coach station, for terminal buildings and for easy transition to the Underground system.

Any really suitable site, apart from Earls Court, is extremely hard to find. And, given Earls Court, the business of handling airport traffic through the Underground railways would be relatively simple. Without a doubt it would be costly. Against that must be set the fact that London airports are destined to handle a great deal of traffic which would otherwise have gone by sea and would have involved expenditure on providing extra transport to and from the ports. It will likewise take over traffic to various parts of Great Britain which would otherwise fall on the railways.

Expenditure on communications between London and its airports can be offset in the next ten years against expenditure in amplifying communications between London and other places. The Government would be wise to reconsider their decision about Earls Court. An exhibition hall is easier to create than several sets of communications radiating separately from London to three airports. At Earls Court is a centre almost ready-made. It would serve as a focus for lines running to the western airports and would make the planning of them easier and relatively economical. It would allow a first-rate terminal to be created.

In the long run it will probably be superseded. Given good services of Underground trains, the public can be expected eventually to make their own way to the airports as they make their own way to railway stations, but there will be a fairly lengthy interim period in which they will need shepherding. The traffic cannot be evenly spread over the working day. Take for instance one trustworthy forecast of peak intensity for air traffic on the European and home services for 1951. The outward peak is expected to be between 7 A.M. and 8 A.M. In that hour about 900 people will have to be moved. The inward peak of about the same total but of lesser intensity will occur between 5.30 P.M. and 8.30 P.M.

Surface transport will need careful organisation and adjustment. For that reason a central terminal is desirable. And while the system of surface transport is accommodating itself to the peculiar needs, the public should gradually acquire the habit of taking train right into the airport. Until that condition is reached, Earls Court seems to me the best possible place for a main terminal.

Mr. H. F. Cronin

Sub-Surface Works

Introduction

Probably one of the commonest, though perhaps not the most unnecessary, causes of traffic delays is due to openings in the carriage or footways for the laying, repairing or inspection of pipes, cables and sewers. If the motorist, while waiting for an opportunity to pursue his journey, cares to look into one of these openings, a casual glance will convince him that the congestion of traffic on the

surface is equalled by the congestion of pipes, cables, manholes and apparatus below the ground.

Every dwelling must at least have a water supply and a connection to the sewer ; no one would now be satisfied without a supply of gas or electricity, or both ; to many persons the telephone is a necessity ; while numerous factories and offices require hydraulic power. Beyond these services there is the prospect of district heating, i.e. the delivery to premises of hot water or steam from central heating stations. All the pipes, cables and apparatus for the supply of these essential services, without which London would be uninhabitable, must, of necessity, be laid under the streets.

Before making a reference to the effects of the London Plan on the Public Utility Undertakings, it will perhaps be helpful to set out a few notes on the type of sub-surface works belonging to these Authorities which are to be found beneath the London Streets.

District Heating

Although installations have been in existence abroad for some years, little information is available as to the form this will take in this country. A Committee of the D.S.I.R. are investigating the matter and their report is expected at an early date. It would appear that water at a temperature of about 300° F. and a pressure of 50 to 60 lb. per square inch will be the vehicle for conveying the heat, though steam may be used in industrial areas. It is contemplated that the heat energy will be obtained from electricity generating stations and that the pipes conveying the hot water to the district will have diameters as great as 24 inches. These pipes will be lagged and laid in concrete ducts, thus adding another type of service to the already overcrowded space beneath the streets. For this reason it is difficult to see how district heating can make much progress in the inner parts of London, except in certain limited areas which have been specially laid out, but if the heat can be provided at a reasonable price, this service should be welcomed, and in the outer areas its distribution will be a more simple problem.

Electricity

London is entirely dependent upon coal-burning generating stations for its supply of elecric current, and a large proportion of the current used in the County of London is generated within that area at selected stations and at a few others. The distribution and sale of electricity is controlled by eight private companies and twenty-five local authorities.

The transmission and distribution of electricity in the County of London is entirely by underground cables laid under the carriage or footways. These cables may either be laid direct and protected by a concrete slab, or they may be laid in ducts consisting of one or more 4-inch diameter pipes.

In the case of older electricity supplies, some cables laid in cast iron or wooden troughs and surrounded by bitumen are still found in service.

When lines of ducts are constructed provision is made for the future. As cable drums containing more than 200 yards of cable are too heavy to handle with ease and it is difficult to pull longer cables into ducts, jointing pits must be left every 170 to 200 yards in the case of lines of ducts, while for buried cables the joints are sometimes housed in buried pits.

For distribution purposes it is usual to lay a cable in the footway on each side of the road or street so that the connections to consumers' premises do not require to be laid across the carriageway, and new supplies can be laid on by opening the footway outside the premises concerned and inserting a tee.

Cables are found at various depths depending upon the space available when they are laid, but the modern practice is to provide not less than 18 inches of cover for low voltage distributors and 24 inches for high voltage mains, adding 12 inches in each case when laid in carriageways.

In a congested area blocks of cable ducts, having a cross sectional area of approximately 4 feet by 4 feet, may be encountered. Naturally the greatest concentration of cables occurs in the vicinity of the power stations, from which cables radiate in various directions.

The voltage carried by buried cables in London varies from 66,000 down to 200. It is becoming a general practice to use voltages up to 11,000 for distribution, and to provide numerous small transformers dispersed throughout the area rather than to supply low tension distributors from a relatively small number of large transformer sub-stations.

The mileage of buried electric power cables in the County of London probably approaches 10,000, but it must be remembered that there may be as many as 30 cables in any one route, while in another there may be one or two.

Gas

Almost the whole of the gas distribution system is composed of cast iron mains ranging up to 48-inch in diameter, though there are some short lengths of steel mains. As gas

mains have to be laid to a fall so that condensate can be collected at low levels, the choice of a path for them is not so simple as for water mains.

The service mains for gas are, as far as possible laid under the footways, and it is the usual practice to lay duplicate gas mains in important streets so as to avoid laying the connections to the consumer across the road. These connections are usually made of steel or wrought iron pipes protected by hessian impregnated with bitumen or pitch in troughing. Gas pipes are found within a couple of feet of the surface but are usually laid with a cover of between two and four feet.

A recent development in gas distribution practice is to transmit gas at high pressures of 50 lb. per square inch as against the usual few inches of water, and to feed this into the distribution system through governors or reducing valves situated in buried pits.

There are probably about 4,000 miles of gas main in the County of London.

Hydraulic Power

The London Hydraulic Power Company owns a system of mains about 183 miles in length through which river water, at a pressure of 700 lb. per square inch, is supplied for power purposes in an area adjacent to the River Thames and in the West End. The pipes used for this purpose are of steel and cast iron and vary from 2 inches to 10 inches in internal diameter.

Sewers

In the County of London the main, intercepting and storm relief sewers are the property of the London County Council, while the smaller sewers discharging into them are vested in the various Metropolitan Borough Councils. Generally speaking, the sewers are deep, for example, of a total mileage of 386 belonging to the London County Council (excluding the Southern and Northern outfall sewers) 278 miles, or 72 per cent. have a cover of 10 feet or over. Very large chambers, etc., have been built for storm water overflow weirs and for other purposes but they are usually so deep as not to affect the other sub-surface works. The sewers are mostly constructed of brickwork surrounded by concrete, and the house connections are made by stoneware pipes.

Since sewers have to be laid to a fall to conform with the general scheme for an area, they cannot easily be diverted like gas and water mains. Manholes must be provided for access at fairly frequent intervals and also in the case of small sewers, manholes have to be provided for changes of direction.

Throughout London, access is provided to many of the sewers in the carriageway by means of side entrances opening from the pavement. These side entrances sometimes cause a serious obstruction to the laying of mains, especially those of large diameter, if they are not sufficiently deep to provide space for the pipe and the requisite cover for its protection.

Telecommunications

The provision of an adequate telephone service has now become an essential of everyday life, and the use of the telephone for more and for longer distance calls is daily on the increase. This and the telegraph service, to which is linked the teleprinter, are grouped under the heading of Telecommunications and are the monopoly of the General Post Office.

In busy towns and elsewhere, where the number of wires required is sufficient to justify the laying of underground cables, this form of construction is preferred. The cables are drawn into conduits laid in advance of requirements and provided with jointing chambers at suitable intervals for access for installation purposes, and also, in the case of local distribution, for making branches from service cables.

Conduit routes may be formed of spigot and socket self aligning glazed earthenware ducts of 1 to 9 ways laid in combinations up to 20 ways, or of single octagonal glazed earthenware ducts arranged in blocks of concrete of from 20 to 100 ways. Such groups of ducts may have a cross section of over 20 square feet, thus occupying considerable space below the ground.

Jointing chambers may be shallow pits in the footway measuring about 5 feet long by 3 feet wide and 3 feet deep, or they may consist of large underground chambers measuring up to 5 feet 6 inches wide by 12 feet long, and as much as 10 feet high (outside dimensions in both instances). In such cases the jointing chambers would be well below the surface and be reached by a short shaft covered by a small manhole cover.

The extreme difficulty and the excessive cost of finding space for additional conduit routes at reasonable depths for main cables through congested City streets, has led to the study of the economic possibility of constructing a deep level system of tunnels so as to cater for future requirements, but it is understood that no decision has yet been made as to this policy.

A certain number of subways and tunnels of moderate depth have long been in use for large cable routes, but during the war a

system of tunnels 8 feet in diameter, at about 100 feet depth, were provided to link up vital centres with the underground tube railways and Post Office parcels railways, and in some instances to accommodate repeater plant. In all, some 1½ miles of such tunnels, formed of concrete sections in the London clay and of cast iron sections in unfavourable ground, have been constructed, and these, in conjunction with the tube railways, have provided a means of securing safety for main cables running out of London through vital areas of the City most liable to bombing.

The locating of a new telephone exchange involves a very close study of the whole cost of the underground plant which will be required to connect it with the subscribers whom it will ultimately serve and with other exchanges to which junction cables must be run. Where a site at the ideal centre is not available, the additional costs of underground plant over and above that required for the ideal site are calculated for such alternative sites as are available, and the best compromise is adopted.

Water Supply

The Metropolitan Water Board own about 4,000 miles of mains in the County of London, ranging from 3 inches up to 48 inches in diameter, and containing water at pressures up to and sometimes exceeding 200 feet head. Practically the whole of this mileage is composed of cast iron pipes, but some short lengths of mains have recently been laid in steel. The cover may be as little as 2 feet, but is usually greater, and it has to be remembered that the depth at which water pipes have to be laid is determined not only by the protection to be given against traffic, but also to prevent the water in them being frozen.

The house connections are made by lead pipes, and in many instances duplicate mains are not laid so these communication pipes pass across the carriageway.

Valves are inserted at all branches and at suitable points to enable the water to be shut off in the event of bursts or leakages, and these valves are frequently located in the carriageway.

Attached to the mains are some 35,600 fire hydrants, each requiring a valve at the branch and a pit in the pavement. For the purpose of emptying the mains connections are made to wash-out pits and thence to the sewer.

In common with other Public Utility Undertakings, great difficulty is experienced in finding paths for new mains into London. Since over two-thirds of the water supply is obtained from the Thames in the vicinity of Hampton, the older roads leading into London from the West are practically carried on water mains. For example, at Notting Hill Gate there are 1-36″, 5-30″, 1-6″, 1-5″ and 1-3″ water mains. Add to this 1-24″ and 2-14″ gas mains as well as the General Post Office and electric cables and it will be appreciated that the sub-surface of the 36 feet carriageway is extremely congested.

For this reason consideration is being given to the laying of further trunk mains in deep tunnels driven through the London clay, and one of the problems requiring solution is the design of a tunnel lining which in itself will form the pipe and be capable of remaining watertight under heads of 200 feet or more.

How the London Plan affects Public Utility Undertakings.

Having very briefly described the pipes and apparatus which are laid under the London streets, it is now desirable to consider how these will be affected if the London Plan is put into operation.

In the first place the rise in the standard of living, which will be accelerated by the rebuilding of the slum and other areas, will be accompanied by demands for greater supplies of electricity, gas and water, and though the density of the population is to be reduced, the increased consumption per head will lead to a total increase in the supply. So far as water is concerned, this extra amount must come from the Thames in the West, and this will necessitate laying further large diameter mains into the County from that direction. It is not anticipated that many new gas mains will be required though the coming of regionalisation may require some additional mains for intercommunication purposes.

Unlike the other Public Utility Undertakings, the telephone service has not only to deal with calls originating and terminating in the London area, but also a large and increasing volume of trunk calls into and out of London from all parts of the country and even from more distant places.

Thus the General Post Office will be faced with the problem of laying both local and long distance cables, and as the main roads entering the County of London are already overcrowded with pipes and cables, the solution may only be found in the construction of deep tunnels for the long distance cables, the local cables having perforce to remain near the surface.

The County of London is now on the whole adequately sewered for the present state of

development. Where streets are altered or diverted it may be necessary or desirable to divert sewers, but this may not always be practicable or expedient. When heavy buildings are constructed over shallow sewers it is often necessary to construct special protective works to protect the sewers.

Redevelopment of London is likely to involve the construction of many new sewers by the Metropolitan Boroughs who will probably, in general, wish to provide a brand new sewer in each street rather than make do with the existing sewers, many of which are obsolescent. The County Council's sewers are not likely to be affected to the same extent.

The proposed sunken roads often involve difficult drainage problems, which must be considered very carefully in the preparation of such schemes.

The effects of the works proposed by the London Plan upon the mass of pipes, cables and apparatus laid below the ground will be considerable and will involve an expenditure of no mean order. To carry out the proposals in the London Plan it is intended to widen and divert existing streets, to stop up certain streets, to incorporate existing streets in public open spaces, and to construct new streets, a few of which are to be carried across the centre of London in tunnel. In addition, pedestrian subways are proposed and the ever recurring question of the provision of subways for pipes and cables is raised.

The widening of any street will almost certainly involve the extension of the carriageway over what is now the footway. This in turn will necessitate the diversion of a considerable amount of apparatus to positions under the new footway, since it would be most undesirable to leave the connections from the various services to premises under the carriageway. Further, in the case of the Post Office and electricity supply cables, the manholes provided for pulling in further cables could not in many instances be left under the carriageway without causing serious obstruction to traffic and danger to men working in them. Lastly, there is the fact that the cover of much of the apparatus laid under the footways would not give sufficient protection from traffic, and, in consequence these pipes, etc., will have to be lowered.

These facts are not put forward as a deterrent to street widening—far from it—but merely to indicate some of the problems which must be allowed for and which must be included in the cost. This may be of the order of £20 to £30 per yard where smaller pipes and apparatus are concerned, and is probably only a small proportion of the expenditure on hand.

The discussion on apparatus beneath the footway provides an appropriate opportunity to refer to the report of a Joint Committee recently set up by the Institutions of Civil Engineers and Municipal and County Engineers on the Location of Underground Services, in which agreed relative positions for the various pipes and cables under the footway are recommended. It is sincerely to be hoped that these recommendations will be adopted by all concerned.

The diversion of existing streets and the proposal to sink or raise their levels involves extensive diversions of mains and cables. To give an idea of the cost involved, an estimate has been prepared of lowering the following apparatus 10 feet, in the case of a road paved with wood blocks on 12 inches of concrete :—

2-4″ and 1-18″ gas mains.
1-3″, 1-6″ 1-18″ and 2-30″ water mains.
Two groups, each of 9 way, telephone ducts.
Two groups of electric supply cables.
1-6″ Hydraulic power main.

Together with all the valves, pits, manholes, etc., attached to them, this might easily run into £200 per lineal yard.

The problem does not end here, for if the surface of the street is lowered considerably the position of the sewer or sewers may be affected and the Inner Circle Railway or other railway tunnels may come into the picture.

In cases where it is proposed to carry roads under parts of London in tunnel the alignment of the tunnel, to avoid interference with sewers, will need careful consideration and the rearrangement of the Public Utility Undertakings' apparatus in the vicinity of the tunnel entrances where cover will be shallow will involve some careful planning. It would be a great convenience if provision were made in these tunnels for certain pipes and cables.

From everyday observations it seems difficult to believe that any success will attend the efforts to persuade pedestrians to use subways across streets as the average Londoner appears to prefer to walk across the carriageway than to descend to a subway. Obviously, if subways are to be made attractive, they must be made as shallow as possible and this will entail the diversion of all the pipes and cables in the carriageway below the floor of the subway. It would seem better policy to make the traffic, rather than the pedestrian, go below ground as this involves no physical effort, and if no alternative route is provided the traffic will have no choice. Here again, however, the provision of sufficient cover for pipes and cables is a

difficulty, though the same necessity does not exist for keeping the subway as shallow as that for pedestrians. On the other hand, a larger subway both horizontally and vertically would be required.

Public Utility Undertakings and Traffic

From the traffic point of view there would be no objection to Public Utility Undertakings' apparatus under the streets if no openings in the carriage or footways were necessary, or if no settlement occurred in the trenches in which this apparatus is laid. Unfortunately it is too much to hope to achieve this, but much can be done to reduce these road openings to a minimum.

The largest openings, and probably the most important from the traffic point of view are those made when new mains or cables are laid. The laying of such apparatus to meet increasing demands is necessary and since the new pipe or cable lines often extend for some distance to enable them to be connected with a source of supply, it is not usually possible to undertake this work when individual streets are being repaved, although much can be done to reduce inconvenience from this cause by co-operation and intelligent anticipation.

An objectionable feature so far as the highway authority is concerned, is the laying of service pipes and wires across the carriageway where only one service main is in a street. If settlement occurs in the cross trenches a depression may be formed across the whole road, and in any event if the service pipe gives trouble or has to be renewed a trench has to be opened at right angles to a line of traffic. This can be avoided by providing duplicate mains, i.e. one on either side of the road, and although this procedure increases the first cost the author is of opinion that the laying of such mains in all streets carrying appreciable traffic is fully justified.

Under the London Traffic Act of 1924 arrangements are made whereby statutory undertakings are notified in advance of roadworks which will involve the closing of one third or more of the width of a carriageway, and they are prohibited from breaking up the carriageway, except in emergency, for twelve months after the completion of the roadway. This scheme—although rather cumbersome where so many authorities are involved, as in London—works well, but as a general rule the Public Utility Undertakings have to complete their work before the roadworks are commenced. It would be a great advantage if arrangements could be made, as was done in Piccadilly in 1927, for the whole of the road to be closed, the surface to be stripped, and then for all the Public Utility Undertakings to come in and do what repairs, renewals, etc., are required, after which the new carriageway could be put down. It is doubtful if this system, which might involve diversion of traffic for a longer period, would result in any more inconvenience than where the Public Utility Undertakings have to break up the surface of the road before the local authority strip it and immediately lay down the new surface. The same procedure might well be adopted where existing streets are to be widened, and in each case the Public Utility Undertakings should receive at least six months' notice in normal times, and longer until the supply of material is more regular, so that they can prepare their plans and order and obtain delivery of the required pipes, cables, etc.

It will immediately be suggested that the provision of subways would do much to prevent the disturbance of the road surface by the laying of new and the repair of existing apparatus. While this cannot be denied, there are certain disadvantages inherent in a system of subways which, except in the special cases of certain congested crossings or intersections of roads, render the use of subways undesirable. These are the expense of diverting existing mains and cables into the subways, the damage caused to other services by the breakdown of one of them, the difficulty of keeping the subways drained and ventilated, and the reduced carrying capacity of electric power cables as against that of cables laid in the ground due to the lesser dissipation of heat. There is also the difficulty of renewing pipes and also of anchoring of water mains.

The great weakness of lines of pipes and that causing most openings for repairs, is the leakage due to defective joints. When pipes are being laid, too much care, therefore, cannot be devoted to the making of the joints, and this directs attention to the efficiency of the staff. The Metropolitan Water Board recently opened a school for training jointers, and at which opportunities were taken to test the skill of the existing jointmakers, which was found to be lower than might be expected. Fewer joints can be achieved by the use of longer pipes, but unfortunately the use of long pipes in many of the streets in the County is not practicable because of the obstructions caused by other apparatus. In any event, all tried improvements in the methods of making joints should be adopted so as to reduce traffic delays from this cause of leakage.

So far as elecricity supply and telecommunication cables are concerned, one of the chief causes of faults is due to damage occasioned by other public utility openings

and the penetration of water into the cables rather than to defects at the joints.

Bursts or failures of mains and cables are sometimes due to the operations of other Public Utility Undertakings in driving headings which are not properly filled up—and incidentally it is very difficult to fill a heading completely—and also from corrosion which may at times be caused by stray electric currents. In this respect the tramways were the worst offenders ; so far as London is concerned their days are numbered and no one will regret their passing. The mileage of electrified railways operating without a fourth insulated rail is increasing and under the London Plan will increase still further. As far as the author's information goes there are no regulations governing the return current from such railways, which operate on private property, and stray currents from this source may well produce all the trouble which was experienced from tramways.

Conclusion

The effects of the London Plan upon the very extensive sub-surface works will be considerable, and when proposing street diversions, road widenings, subways and tunnels it is very desirable that the planning authorities should give early consideration to the diversion and re-location of the mains, cables and apparatus involved. In this connection it should be pointed out that while a street may be completely closed to traffic and motor cars, buses and lorries diverted into neighbouring streets, the flow of gas, water and electricity in the pipes and wires beneath the street must be maintained and if it is necessary to interfere with these, they cannot be cut off until other pipes or cables have been laid in substitution. Nevertheless, the Public Undertakings will welcome the provision of new and wider streets and the opportunities provided by wider footways and grass verges in which, at least, the service mains and cables can be laid.

Although this paper has been almost entirely concerned with the apparatus beneath the streets, it has to be remembered that all these wires and pipes must be connected to works where the particular commodity which they are carrying is produced or disposed of, and that provision must be made in the various plans for sites for the works. While the planner of a new building estate may reserve space for water pipes, and these may even be laid in advance of the building, they will be useless unless the authority is given timely notice to provide the necessary water with which to keep them charged.

One fact which is apparent from whatever angle the London Plan is examined is the need of co-operation between all the authorities involved and the early notification of concrete proposals by the planning authorities, coupled with a request for observations thereon by the Public Utility Undertakings. It would facilitate matters and hasten the execution of the works if the proposals and counter proposals could be dealt with by a small representative Committee, who would reconcile the conflicting interests, especially in the thorny question of payment of costs, but whether such a procedure would work satisfactorily in an area like London with its multiplicity of authorities, is open to grave doubt. But if the plan is to be made to work, and to work quickly, a Committee of engineers might well be appointed to examine and report upon what may be described as the engineering implications of the London Plan.[1]

Mr. J. C. Martin

Underground Railways

FOLLOWING Mr. Robertson's graphic paper on railways, I am privileged to-day to address you shortly on one phase of planning which is contributory to the great scheme still to be worked out for the reinstatement of London coupled with improvements in manifold directions which have already been suggested by eminent people and bodies.

We have not yet really begun to plan ; we have done little more so far than to ventilate the subject in text and so awaken a very lively interest.

As a railway man with more than 50 years' experience on the design and construction of railway works, and in that time 43 years of similar experience of deep level tube railway works, I hope to interest you in some of the practical work that must be done if such a scheme as the Railway (London Plan) Committee presented to the Minister of War Transport in January of this year be accepted *in toto* or in part.

This scheme was drawn, as it states, with a proviso that half the Southern Railway terminal stations will be abandoned as suggested in the County of London Plan, 1944, as it lays down what will be necessary in replacement to bring all those people living southwards of the river Thames into the

[1] The author expressed his indebtedness to Mr. Beckett of the Building Research Department, Mr. Escreet of the Gas, Light & Coke Company, Mr. Leach, Mr. Partridge and Mr. Whitcher of the Central London Electricity, Ltd., Mr. Frost and Mr. Edwards of the General Post Office, Mr. Smith of the London Hydraulic Company, Mr. Warlow of the London County Council, Mr. Lloyd Roberts, Mr. Curd and members of his own staff, for their help and criticism in the preparation of this paper.

City and the 'West End' for conducting their daily work.

The scheme does not stop short with reinstatement, but wisely includes similar facilities for the suburban services of the other main line companies, which, following the Southern Railway's example, are already embarking on general electrification.

The planning of additional tube lines is also included in the scheme, for the reason that it would be folly to construct the lines required in the first instance with any risk of 'barriage' to future development.

The subsoil of London is already becoming congested due to the development of the Transport Board's tube railway system, the Post Office (London Railway) and the network of the main drainage system, and so the planning of the new railways, in larger tunnels, will need a great deal of thought. The under-river crossings of twin tunnels at eleven places add to the difficulties of grading and routing.

It will take some years, under the closest co-ordination with everybody concerned in the major planning, to arrive at the stage when construction can be begun. The main line railways must scheme out the widenings of many of their lines, the proper location of a score of tunnel portals has to be determined, rolling stock depots will need to be designed—all before submission to Parliament of the plans necessary for obtaining the powers to construct.

As a general rule, these new lines will have to be built in zones of the subsoil, beneath those already occupied by existing works; the character of the lower strata must be explored by boring in some hundreds of places, before it can be determined to what extent working in compressed air can be avoided. The siting of the station tunnels, their alignment and the run of the tunnels as a whole, will require the most careful study, as curves of very much greater radii than was thought allowable, in the early part of this century, for the smaller diameter tubes, must be used. In those days 6, 7 and 8 chains radius curves were permissible; for these new lines we must design suitably for the running of larger and heavier stock at considerably higher speeds than on the earlier tubes. The ruling radius should not be sharper than 20 chains except for short lengths on approaching and leaving stations, where 15 chains might be permitted in extenuating circumstances.

Owing to the much greater length of train, 650 feet instead of 350 feet on the existing tubes, and the correspondingly increased number of doors to be kept in view of the guard whilst the train is loading, these new platforms should be straight or built on such an open radius that there is full sight of all doors from the guard's position at the rear of the train: these conditions create much difficulty in bringing the new stations in close proximity to the present stations and in arranging convenient passages for interchange.

The original tubes were designed by engineers of distinct and separate companies, and interchange below ground was completely disregarded; and it was not until they were almost completed by the Underground Electric Railways Company of London, Limited, as a combine, that interchange passages and stairs were added, in the poor but best way they could be designed in the circumstances. The interchange problem will need a great deal of solving at those places where two or three new stations are intended to have intercommunication with two existing stations; I have no fear, however, that satisfactory and convenient arrangements cannot be made.

The building of the original sections of the Bakerloo, Piccadilly and Hampstead tubes in the years 1903 to 1907, with an aggregate length of about 23 miles, taxed all the resources of the London contractors capable of doing this specialised type of work, and the iron foundries in the North were hard put to it to supply the requisite daily quantities of iron tunnel lining—the 23 miles, of railway needing about 13,000 tons per mile, or about 300,000 tons in all. The building of this group of main line sized tubes will consume at the very least 3 million tons of iron, but fortunately in a longer period of time.

Another problem will arise in respect of the disposal of the excavation. In the early days vast quantities were despatched to Peterborough and tipped into worked-out clay pits of the Fletton Brickyards, a great deal of the spoil was disposed of in old gravel pits in the London area, and the remainder, being the Bakerloo excavation approximating to half a million cubic yards, was discharged into barges at the river shafts at Hungerford Bridge and dumped in the Thames Estuary at a point eastwards of the Nore. There will be well over ten times the spoil to be disposed of in this scheme, and every site in the London area is full to overflowing with rubble collected from shattered buildings during the war. It is a little difficult to visualise 15 million cubic yards of clay. One square mile 15 feet deep is another measure of it.

Few people other than those who have been intimately engaged on the design and construction of tube railways can have any idea of the intricacy of planning the details of such works. In order that you may have

an insight of this, we have arranged a small exhibit of simple models, detail drawings and setting out plans, which I am quite sure will be of interest to you. Travelling by these tubes after they are completed, you pass in sequence from the pavement, down a stairway, traverse a sub-street Booking Hall such as Piccadilly Circus (which was constructed without disturbing one single vehicle using the streets and took two years to build), descend the escalators—perhaps unconscious that, beneath the ticket hall floor, there is a spacious machinery room for the motors and gearing which drive the escalators, and that beneath the escalators there are the provisions for the endless chain of steps to partially fold and pass upwards again to resume their visible functions—and, after negotiating the half-way landing, you are directed either to the right to the Bakerloo Line or to the left to the Piccadilly Line, and eventually, by walking only a few paces and negotiating the very minimum number of stairs, you board your train without even being put to the trouble of opening the door.

No two stations are alike. Geographical positions and varying levels cause each station to be designed quite independently. There is no type ' X ' and ' Y.'

Before any of the works can be constructed there is the ' nightmare ' of setting out, and all the tedious and intricate business of making the surveys by night, when the streets are empty ; nine times out of ten this work has to be done in the late autumn and winter months in fog, sleet, rain, frost and snow, and I assure you it is a wearisome task. Time does not permit me to describe to you the standard of accuracy of these surveys and setting out, but you can gauge what I mean when I remind you that the complete knowledge of the survey on the surface has to be transferred down to tube level by measurements and angles *via* a couple of steel wires plumbed down the working shafts which are only about 11 feet apart. Notwithstanding this ' pinchbeck ' limitation of our base, we are able to drive the tunnel between the working shafts, which average about half a mile apart, and meet together at the halfway point within a variation of distance line and level inside the diameter of a sixpence. If we didn't do this, I need not tell you that we would not be asked to try again. Some people wonder why a tube railway engineer gets paid about twopence an hour more than his colleagues who work in the daylight and in the good fresh air. There is no ventilation in tubes until they are finished.

In my way of thinking, all this is compensated for in the stage preceding the construction, when one has that positively fascinating job of designing what afterwards has to be built ; and I assure you an alert mind and keen vision are necessary if you are to get as much fun out of it as I have had. In my younger days I scarcely knew when it was time to go home, and I hadn't much use for Sundays.

(At this stage the speaker showed a number of lantern slides.)

I spoke of ' working under the closest co-ordination.' I said ' we have not yet begun to plan seriously.' The position, I suggest, is becoming very acute, and some way should be found at the earliest possible moment to establish in reality a beginning of London's reinstatement. Do we not require :

(1) to set up a Select Committee or Commission of practical people, to work continuously, all and every day ;
(2) to formulate the work, in the proper order ;
(3) to see to it that estimates are given in terms of money and time for everything needed ;
(4) to avoid the destruction of good and bad alike in order to create some grandiose change in this London of ours and so make it unrecognisable?

London's present disfigurement must not be allowed to continue indefinitely, which it assuredly will do if we proceed on the lines of the verbal and pictorial plans which have been suggested by eminent people and Associations who may not be realists.

Communications must be planned first, and in the order railways and then roads. The wholesale removal of main line railway termini to new sites is, I suggest, unnecessary and a needless extravagance (each about a 20 years' job, creating an incredible traffic chaos of which few of us can hope to see the end). In this case all that great and enterprising system of underground railways now existing would become dislocated and practically useless. The railwaymen must form a strong part of the co-ordinating body.

In regard to roads, there must be a very strict limitation on what is done. Mr. Cronin's paper is a warning to those who plan new arteries (without supplying estimates) regardless of the hundreds of millions of pounds which have been spent in building up all those utility services closely beneath ground level, notably the primary drainage system, water, gas, electric power and light, telephone lines and the hydraulic system. I judge it inappropriate (to say the least) to draw a road which involves building over main thoroughfares. The County Council's main drainage system is about as immovable as anything I know of, and for them to have

to ask permission of the lady of the house to enter and remove the drawing-room carpet as a prelude to making their weekly incursion down the manhole really does appear to be a little odd. The road engineers must deal with this problem and, presumably, must content themselves with judicious and economic widenings, excepting where slum clearance may offer them a little more scope.

Buildings, in my view, must come third on the list, except in large devastated areas, where rebuilding is already long overdue. They are, of course, of the utmost importance in the plan. My one plea is that we do not regiment monolithic blocks of buildings in geometrical patterns all over London as many of the published plans depict. If we do, we shall forever lose 'our London.' Who but the draughtsman, looking down at the small scale project on his board, can see all at once the four sides and corners of a great square or diamond-shaped setting out? No one, I suggest, but the individual who first buys himself a balloon.

It is my firm belief that a co-ordinating body of some twenty people, chosen for their judgment and proven technical knowledge of their separate professions, and supported by the properly staffed draughting offices they would need, could produce within two years a practical plan for London, provided that their work was uninterrupted and that they were such men as would reasonably combine as a team.

I do not know what is the total assessment of London's war damage, nor have I much cognisance of the magnitude of the sum we might expend over a term of say 25 or 30 years, which I contend is a reasonable period of time, for the expectation of reinstatement. This is the first thing to be determined, otherwise planning in detail will be an utter waste of time.

It is going to cost money to set up such a commission, perhaps as much as it would cost to replace a Branch Bank building in some devastated part of the City. We dabble in thoughts of spending thousands of millions of pounds, but we jib at spending a hundredth part of one per cent. of it to study the problem seriously.

This is not idle levity. I can only open my mind to you in my own way. I hope for the best approach to such replanning as we can afford, to be instigated as soon as possible. We should not be depressed at the trend of things but put a good face on it and get to work in a proper way with energy, sensibility and a sound sense of proportion.

Third Session: Discussion

Sir William Halcrow (Chairman)

First of all, I should like to ask whether there is not a danger of planning on too large a scale, and I ask that question for several reasons.

First, what will be the future population of London? Statisticians tell us that the population of the country as a whole will decrease at some period, perhaps not so very far ahead. Also, the Government policy is to establish satellite towns at a distance from London, and some Government Departments are being set up in other parts of the country. Will these developments have the effect of reducing, or retarding the increase of, the population of London?

The area of London is limited, and the space for the building of offices, etc., and the accommodation of workers cannot very well increase unless we change our building policy and erect sky-scrapers. Is there not some limit to the number of workers who will require to come to London daily?

Further, it has been suggested that considerable areas south of the Thames should be cleared of their present buildings, and large blocks of residential flats erected. The effect of increasing the living population in South London would appear to me to indicate a reduction of suburban traffic.

I should like to suggest that the problem of railways and the problem of roads be dealt with separately. Railways are dependent upon the travelling population only, whereas the roads are not. They are dependent upon the number of vehicles which use the roads, and the number of vehicles may increase irrespective of the population. Again, railway technique and railway building is not such a difficult problem as that of road planning and building.

In connection with railways, I suggest that immediate steps should be taken to relieve the congestion on some of the lines existing to-day. New tubes could be built fairly quickly, and could be planned so as not to interfere with larger schemes which may develop during the next 20 or 30 years. If, as was suggested yesterday, a Committee or Commission is established to plan London railways from beginning to end before anything is done, such planning and consideration may take years. At the end of that time the plan prepared, and the estimate of its cost, may be so big that those responsible for the finance of such undertakings would feel that they could not go forward. They might return the scheme and ask the Committee or Commission to start all over again and to produce something having

some relation to the economics of the whole matter. Much valuable time would thus be lost, and it does seem to me that the most urgent requirement is that what can be done should be done to relieve the present congestion.

The road problem is very much more difficult, and no doubt we shall hear the views of experts as to what should be done. It has been suggested that overhead roads might be preferable to the digging of tunnels, and that a section of overhead road might be built in order to try out the scheme. That is only one of the suggestions made, and I hope we shall hear more during the discussion.

Lieut.-Col. Mervyn O'Gorman, C.B.

THE interesting symposium of September 12 was a 'prospectus' inviting the London public or the Government to make a remunerative capital investment (which Lord Latham put at 'over £100,000,000') in the profitable business of curing traffic delays and accidents. But the promoters made a grave omission. They gave no estimate, or even a rough guess, of the total capital they would profitably utilise, or of the annual return expected on that investment. If the cost of traffic delays in London approaches to that estimated for New York, London's investment could earn (by losses avoided) some £50,000,000 a year, which is enough to warrant any capital outlay under £1,000 million. I do not advance these figures, but I say that a reasoned estimate from the promoters would give a backbone to the whole discussion. An official estimate of the loss by traffic delays is wanted anyhow, on the lines of Professor Jones's recent estimate of the cost of accidents in Britain (£100 million per annum). For the latter the Ministry of Transport is to be thanked.

The new constructional work will take a long time, and during that long time we cannot endure the 300,000 casualties a year in Britain which Sir Alker Tripp handsomely admitted. I call it handsome because he has, however unintentionally, his share in the responsibility. He says the cause of accidents is somebody's 'horse and cart mentality.' This is superficially correct, but I invite him to dig down deeper into causation—for I agree with one of his critics who said that the problem of circulation and safety are one and the same. Also I do not accept that 'the vast majority of accidents are due to human error,' if by that he puts the responsibility on the road users.

I wish to establish some exoneration of the road user. I begin by drawing attention to the fact that behaviour on the road has developed differently from the behaviour of traffic on the sea. The difference is instructive. The hazards of the sea were tackled by sailors who proved themselves capable of learning how to move ships safely in thousands. They do not collide. The reason is simple. All ships without exception conform to traffic rules, ingeniously contrived to enable any skipper to know in advance the intended next move of any other ship nearby. Observe that the *sine qua non* for safe traffic in any medium is this knowledge of intention. It is summarised by sailors as 'show your helm.' Now for a parable. Imagine that all tramp steamers turn primitive, refuse to carry lights or to obey any rules. This alters the sea picture fundamentally, and not only for the tramps. No skipper thereupon knows for certain where any other steamer will go, since erratic movement to avoid collision has become the order of the day. Insurances rise as foreseeableness declines. Collisions become more frequent whenever the number of ships increases, for the crashes *now* obey the laws of probability, whatever carefulness is exercised. The tramp steamers have adopted the position at sea of pedestrians on land. They defend it as their freedom. Pedestrians cannot be blamed for distrusting the prospect of being regulated by authorities who have for 30 years been regulating traffic without preventing an accident increase to 300,000 a year, and then accusing road users of not taking care. It is impossible for any one to take care. *To take care in traffic is to look out for others, to note the intention of each and to respect it in accord with known regulations so as not to do anything unforeseeable oneself.* The tramp steamers by being unregulated have made this impossible. No skipper of any ship can now take care, not even if the Admiralty were to plaster every funnel with melancholy pictures of sailors' widows.

On land, not only are the unregulated pedestrians unforeseeable by drivers, but drivers have no rule that makes them predictable by pedestrians. The 'rule of the road' only regulates drivers in their relations to one another and only concerns their manner of overtaking and passing other vehicles. It does not require any driver to go to any predetermined place on the road. Drivers may, and do, ride on the left, the middle, or the offside, and swerve from one to the other without any compulsion to signal the swerve. The recommended signal (rarely enforced) only applies to a 'turn,' or to a 'sharp change of direction,' not to those swerves. The rule is 'Overtake another driver left hand to right hand and pass him right hand to right hand.' This is demonstrably insufficient to determine a vehicle's position on the road.

A scientific study of traffic conditions is required, to discover the laws of traffic flow ; to determine the speed of maximum safe output for a traffic lane ; to investigate the desirable height and position of driver's seat for the most economic and safe use of the road surface ; to find the best place for central refuges at road junctions ; to determine the best longitudinal spacing of vehicles for an efficient restart at traffic control points ; to measure the influence of traffic density on (*a*) circulation, (*b*) safety ; to relate counts of accidents to the relevant count of traffic present ; to study the psychology of road users ; to measure the relative road economy of trafficator lights against police pointsmen, to establish the relation between traffic speed and accidents—and other such technical matters, all of which are at present the subject of guesswork as the foundation for emphatic assertions.

Dr. R. V. Southwell, F.R.S.

I HAVE always been interested in what lies beneath the surface of London—an equally fascinating subject from the engineering, archaeological and other points of view. When underground works are proceeding, we presumably learn more about what lies beneath the surface ; but is it not a fact that, at the present time, the information so gained remains in the records of the particular engineer who is doing the job, and is never placed on record for the general good ? As more and more excavations are made in the future, more and more information will be obtained about modern London, Roman London and, perhaps, even pre-Roman London : I suggest that the British Association might exert its influence to arrange for the Ordnance Survey to take up this matter and to try to keep up a map which would reveal as much as is known at any given time about underground London, and which would be available to the public in the same way as the Ordnance Survey Maps of features above the ground. A speaker yesterday suggested that there was ignorance where there should not be ignorance, and I feel sure that the public could assess more easily the problems we are discussing to-day if such maps were available.

It has always seemed to me that not enough use was made in the past of the fact that in London the ground on the north side of the Thames rises fairly rapidly to the north. Quite a number of streets, especially near the Adelphi, have an almost inconveniently steep gradient between the river and the Strand. Need they all come to the same level quite close to the river ? Might not the north-south streets run under the east-west streets until they come to a common level further north ? I should have thought that a clover-leaf type of junction was clearly indicated.

When discussing traffic problems and safety, ought we not to remember that there is something to be done in connection with the design of the motor car itself ? One cannot travel along the roads for long without realising that the average driver has little or no idea where his near-side wheels are. As a result he is wasting eight or ten feet of roadway all the time, and every line of traffic wastes a like amount of space. That is because the design of cars at present, with their large ' battleship ' bonnets and the low, rakish seats so dear to the sports driver, is such that it is not possible, except after a lot of special practice, to know where one's front near-side wheel is. I suggest that this point bears on the traffic problem, because in addition to wasting space ahead, drivers are also wasting side space.

Finally, in addition to my plea that an underground map of London should be made available in the same way as surface maps are available to the public, I suggest that it would be a good thing if air photographs also were more easily available.

Wing-Commander T. R. Cave-Browne-Cave, C.B.E.

IT seems to me that this conference is doing, or has very nearly done, exactly what we wanted it to do. We started with a statement from no less an authority than Lord Latham that the matter was really serious and that something must be done about it. Then we heard Sir Alker Tripp speaking of the requirements of traffic, and the avoidance of accidents ; and he speaks on that subject with greater authority than any other man. He defined the requirement as the provision of channels for high-speed traffic, free from pedestrians, and connected to the normal road system at a few points only, perhaps one every mile.

I think we ought to examine how far it is practicable to meet that requirement. Our Chairman has said, very wisely, that the problem should be viewed in two parts, one the railway part and the other the road part. May I refer to the road problem and suggest a solution which seems to arise logically from the definition of the requirement and the description of the difficulties to be avoided.

The papers presented yesterday indicated that the greatest difficulties and the greatest causes of delay arise from disturbance of buildings, and the alteration of underground services. That leads me to the conclusion that the new high-speed channels have got to be constructed at a comparatively high

level, say about 80 to 100 feet above street level. They should definitely not follow the lines of the main arteries, but should be parallel to them, at a distance of perhaps 100 yards. They must not be on the lines of the main arteries because there they would interfere with and darken the most valuable frontages. Judging from the sections showing what is underneath the main arteries, it is quite clear that those strips of land, filled with mains and sewers, and conduits could not possibly carry the weight of the new constructions.

It seems to me that, parallel to those arteries, at a distance of about 100 yards, there are more suitable strips on which we could build a continuous row of exactly the kind of buildings required in London for many purposes. I have in mind the large steel-framed, flat-top buildings which are being used for blocks of offices, blocks of flats and even factories and warehouses. The fashionable type of large building in London is structurally much the same, whether it is used for offices or blocks of flats or warehouses. The structure of these buildings is such that little strengthening of the members would be necessary to allow the roof to carry a traffic load, provided all vehicles have pneumatic tyres which give no excessive local shock load.

The new high-speed channels might well take the form of a highway on the top of a continuous row of buildings. They would meet the requirement and would at the same time avoid many of the worst difficulties. There would be the minimum of disturbance of existing roads and services, the minimum danger of injuring pedestrians, the minimum of noise (quite an important factor). Instead of the vast quantities of spoil which Mr. Martin produces from the underground scheme, the new by-product would be useful buildings of various types. From such roads there would be the best possible views of London. I have flown over London a good deal, and at very much lower heights than have most people. The airship R. 101 often flew at a height of 1,000 feet or less, and from that height London looks extremely good. If we are to bring people into London on a high-level road they will appreciate London very much better than if they come in by tube.

It seems to me that sufficient is now known about the various forms of development which have been discussed to enable them to be worked out as definite engineering designs, showing the cost, labour, materials and time required for each.

This suggestion of high-level, high-speed roads may be new but it does seem to arise logically from what was said yesterday. It can only be judged in comparison with the more conventional alternatives if all are worked out in definite detail to an advanced stage and preferably with alternative variations of each. Then we can see what is actually involved.

I do not know the cost of the new viaducts, but I should doubt that the cost per mile would be very much more than that of any of the other alternatives. I would suggest that the vast income to be derived from the buildings which carry the roadway is an advantage which no other scheme can claim.

I feel rather that we are faced with a kind of combined operation commensurate in importance with the operation of 'D' Day. Before the proper plan can be chosen many alternatives must be worked out in detail of cost, labour, materials and time. They are vital factors and cannot be guessed. They must be worked out and they govern the choice.

It might be a good plan for this conference to pass a resolution on those lines, and for the Council of the British Association to put it forward as the logical conclusion of this conference.

Sir Alker Tripp, C.B.E.

I AM grateful to Colonel O'Gorman for his remarks. I have done quite a bit of observation of London traffic from the air; flying for the very purpose of observing the traffic. I agree that the roads look rather like a desert—they are so much deserted. But the railways are in exactly the same condition in regard to circulation; seen from above, they show a great deal of waste space. But whereas the railway traffic is co-ordinated, the road traffic is not. If the road traffic were as co-ordinated as the railway traffic, most of the difficulty would disappear. Road traffic piles up at all the junctions, where there is cross traffic; that is bound to happen. The quick clearance that is suggested by Colonel O'Gorman is spoiled by the turning of traffic, particularly at right-hand turns. Pedestrians also have to get through; the traffic units are all unco-ordinated, but all have to be pushed through somehow. If there is any way of getting it through more quickly, I should be glad to know. But, apart from new lay-outs, I do not know of any way, except that in many cases the policeman is very much better than the robot. At the same time, I doubt whether we shall ever have enough policemen to do the job at the same number of places as we can regulate by traffic signals. I think the best course is to work as far as we can towards co-ordinated traffic signals; but under existing conditions it is extremely

difficult. The principle of co-ordinated signals is sound, but the signal points have to be at more or less equal distances one from another if we are to get a satisfactory time/distance diagram, and thus enable the traffic to flow in both directions at a decent speed. Unfortunately, however, the age-old junctions with which we have to deal are far from being at regular intervals; and that fact renders the problem extraordinarily difficult. Within the last month I have done my very best to work out a scheme of signals on the basis I have mentioned, and I have tried in vain to obtain a speed beyond 18 m.p.h. The ancient lay-out is killing the circulation of modern traffic.

I was surprised when Colonel O'Gorman challenged my statement that casualties are due to human errors. No one causes an accident intentionally. I have been studying casualty maps for a matter of 20 years and investigating the causation of accidents; we at Scotland Yard have a code number on each flag, and each number refers to a particular type of cause. Practically all are human errors. I put it another way in my book on Road Traffic. It is the 'unexpected encounter' that we have to try to prevent, but that is extraordinarily difficult when the streams are entirely unco-ordinated.

I agree entirely as to the need for knowledge of the other fellow's intention; if everyone obeyed the law and the 'Highway Code' we should reduce casualties with a run, because we could then depend upon the other party doing the right thing. Unfortunately, however, other people do not obey it; it is a case of human error.

To quote the parallel of the ship master is not, I submit, quite sound because, after all the ship masters do respect the law; they obey to the letter the very complicated Board of Trade Regulations, whereas on the road a very high proportion of road users definitely and intentionally break the rules. Again, except in fog, the ship master has an adequate time-interval in which to keep clear, whereas on the road, as often as not, the occasion occurs instantaneously. That makes an enormous difference.

A point with regard to roads crossing each other at separate levels was made by Professor Southwell. The trouble there is that of accommodating the turning traffic; if you cut out the turning traffic at one junction you double the load at the next, and that in the aggregate may give rise to more difficulty than we have at present. In many isolated cases, however, where there is a predominance of traffic running directly through, simple bridging (as at Holborn Viaduct) is well worth while.

Sir Frederick Cook

ONE question I cannot avoid asking is, what is the London Plan? Mr. Lyddon mentioned four, and they were all official plans. There was also a plan prepared by the Royal Academy and there are other plans of which some of us have knowledge. I cannot help thinking that there are too many London plans, just as there are too many authorities responsible for their fruition, and it may well be that, until some *ad hoc* authority is appointed, with power, not only to evolve, but to give effect to its proposals, we are not likely to get very far.

It would perhaps be true to say that the roads are the very foundation of any town plan, not because of the roads themselves, but because the average citizen thinks first of roads, for they affect his personal convenience more than any concomitant with which we may be dealing. It has been truly said by Sir Alker Tripp that the present road system is not well designed. Roads have been with us from the earliest days of which we have any knowledge. The internal combustion engine has been with us in its practical form for 50 years or so, and we are trying to solve the problems of road traffic in a manner which might be likened to a General trying to win a modern battle with the weapons in use at the time of Waterloo.

Professor Holford expressed regret that the £87 millions per annum, which he quoted as being the proceeds of motor and fuel taxation, is not devoted to the carrying out of such vast improvements as are contemplated in every London plan that I have seen. For that we have to blame ourselves. When the Road Fund was established, shortly after the 1914–18 war, it was the expressed intention of the Government to devote the proceeds of motor taxation to the improvement and maintenance of the roads upon which the motors ran. After a few years the Road Fund accumulated some £20 millions; then the Chancellor of the Exchequer came to the conclusion that that money might be spent on matters which were nearer to his own heart. When the matter was raised in Parliament there was a long debate about it, and it turned out to be a question of either not using the Road Fund for the benefit of the roads or accepting the alternative of an increased Income Tax. All hands went up against an increased Income Tax. The example, once set, was soon followed, until in time the position was reached at which the Road Fund, although it remained the Road Fund in name, ceased to be such in fact. To-day the expenditure by the Ministry of Transport on what might be very useful and desirable road improve-

ments is placed on the same basis as the expenditure of other departments, being dependent on an annual vote in Parliament for the money required.

We have often heard a comparison, made between road and rail administration. I think such an analogy is overdone, for the functions of the two are entirely different in their general applications. Railway traffic runs at predetermined speeds, calculated in conjunction with curvature and gradient. It is confined to a track of uniform width, fenced all the way, from which other moving units are entirely excluded. On the other hand, vehicles on the roads run at speeds which for all practical purposes are within the will of the driver. The track varies in character, and there is ample room for lateral movement. As a general rule the track is used for all kinds of vehicles and for the movement of pedestrians. The motor vehicle, whether it is a private car or a commercial vehicle, is essentially a social vehicle. It can travel long distances at varying speeds, it can run from door to door, and it fulfils many purposes ; under present conditions we cannot dispense with it.

To some extent we can alter the present conditions by constructing roads to be used solely by motor traffic. But there is a limit to which this can be accomplished. Sir Alker Tripp used a phrase critical of a Committee which has recently reported, and which commented upon the construction and design of ring roads. He criticised a statement in its report that ' on new outer ring roads provision should be made for pedestrians.' I happen to be Chairman of that Committee, but he will appreciate that I do not speak about it in any sense personally. The Committee was very carefully constituted. It comprised engineers, architects, town planners, and the police who are responsible for traffic on the roads, and it drew up a report, which was, in general, well received. But throughout its deliberations, and in drawing up its report, the Committee was actuated by a spirit which has been expressed exceedingly well by Professor Holford, who said that ' specialised measures and the carrying out of bold traffic improvements should not be considered as being independent of the economic life of the areas in which they are applied, whether this is carried on in shops, offices, warehouses, factories or farms. They should in fact evolve from it.' That is a sentiment which was borne in mind very thoroughly by the Committee to which I have referred.

The functions of a motor road for motor traffic alone and of a ring road are two different things. A ring road is almost invariably necessary in a wide urban area, to serve the purposes of the inhabitants of that area. To expect to exclude from it other kinds of traffic than motor traffic is something which I think would not be tolerated in the average town. There are conurbations of towns where it is inevitable that through traffic must pass, not necessarily at surface level ; and I am in full agreement that, where purely through traffic has to pass through built-up areas, it should be on highways either overhead or underground.

We have heard a good deal about road safety. I agree that every road improvement is bound to have a beneficial effect on public safety, but sometimes I think we are inclined to concentrate unduly on immense improvements, at huge cost, the effect of which is often problematical. Between the years 1934 and 1938, in which Mr. Hore-Belisha was Minister of Transport, the number of road fatalities was diminished from 7,143 to 6,440. That marked improvement extended over four years, during which time there was an increase of traffic on the roads of no less than 700,000 cars. That improvement was not effected by any huge scheme of road improvements, though road improvements went on all the time. There were other means less spectacular, but happily effective, and I feel that, if work on similar lines were continued systematically, as it should be, we should have results bearing some relation to the improvement which was effected in 1934-1938. For example, in the year before the war, a very ably directed improvement was effected in Lancashire by the adoption of a system of street vigilance, by propaganda and by education, particularly of children, and in that county, in that year, a reduction of no less than 44 per cent. was effected in the number of casualties.

Mr. C. Gribble

We must all be impressed, after hearing the papers and the discussion, by the enormous magnitude of the problem under consideration. I suppose that never in the history of our country has anything of this size ever been considered before as one scheme. If our minds had not been so much affected by the colossal expenditure which was incurred during the war we might perhaps be more staggered than we are now by the terrific expenditure which must be incurred if anything like what is proposed in these various plans for London is carried out. I was much impressed by the Chairman's remark that perhaps we were attempting to plan on too large a scale, for it seems to me that, if something of the order that has been brought to our notice, is considered and a

decision made, it is so enormous that a very long time must elapse before any conclusions can be arrived at by any Government or any body at all.

To my mind, although some of us might consider the scheme as a whole and indivisible, it does divide itself into three parts. There is the reconstruction of the City, made necessary by war devastation ; there is the problem of the roads, which has nothing to do with the war, but was a problem before the war began ; and there is the proposal, put forward in various forms, for a complete reconstruction of the railway system in the south of London, including the terminals on the north bank of the river.

There are different reasons for each of those three. The reason for the reconstruction of the City of London, of course, is obvious. The reason for the complete reorganisation of the roads in London is also sufficiently obvious, because we are told, and probably with truth, that unless something is done the traffic may come to a standstill. We are very glad to hear from the Leader of the London County Council, Lord Latham, that the Council is going to undertake, as soon as labour is available, large schemes of road improvements, schemes which were in fact in progress before the war. But when we look at the proposal for railways we find the cause is not the same. I do not think it has been suggested seriously by anybody that the railways are so far unable to cope with the traffic they are offered, that it is impossible for them to carry on in their present form. I think it is quite clear that to-day there is great congestion of certain parts of the railway system. That could be dealt with by the railways themselves by widening, by new railways, by new tube railways. But I gather that the reason for this extraordinarily complete reconstruction of the railways coming into London from the south is that the planners who wish to reconstruct south London say that they cannot reconstruct if the railways remain. Therefore, somebody has to decide—it is probably the Government—whether they have made out their case and whether it is in fact true that it would be impossible to reconstruct south London with the railways in their present positions. They have also to decide whether, if the elaborate scheme for tube railways under the river were in fact carried out, the travelling public, i.e. the citizens of London, would be in a better position, would be more comfortably transported and would be happier than they are now. About that I have grave doubts.

No decision can be made as to whether it is economically practicable until it has been considered by experts. We all hope that the matter will be dealt with before very long, because at present nobody knows what is going to be done and it is difficult to form an opinion as to what should be done. It is a practical matter for experts, who know what materials and labour are required and are available.

Before anything else is done, an enquiry must be made into this whole problem. If it is not dealt with immediately and broken up into its constituent parts, nothing at all can be done for a considerable time. I think the papers read to us yesterday have thrown a great deal of light on what the problem is ; they must be and will be of the greatest value to those who have to consider this vast scheme.

Mr. J. S. Wilson

HAVING been partly responsible for its organisation perhaps I may be allowed to say that this conference seems to have achieved what we aimed at, namely, to bring forward the various aspects and so enable those concerned to study the problem comprehensively. Plans so far produced have been regarded by engineers as having been drawn from too one-sided a view. Everybody realises that something must be done. That something can only be done if there is an agreed plan, and the agreed plan will have to be the result of a very carefully co-ordinated examination of the whole problem. It is not just a matter of architecture, or town planning, or engineering, or economics, but a combination of all those considerations, all of which will have to be given their proper value. Further, whatever is proposed will have to be based on a certain prophetic confidence that the plan, which must be a very long term plan, will be acceptable to the next generation. It would need not 10 or 20 years, to carry out, but 50 or more years. We should have to assume that the experts of the next generation would be agreeable to follow that plan.

It has been suggested that a resolution might be put. I do not think the matter is sufficiently ripe for that, but our discussions and the information we have obtained will help to formulate conclusions and recommendations. What appears to be necessary is that the Government should set up some body with adequate power. That body should get on with the examination of the problem, the exploration of the ground, and so on. It would take a long time, but the sooner we start the better ; the more money that is used and the more effort made to get things going, the sooner something will be done.

Mr. Henry W. S. Husbands

THE basis of the County of London Plan for the roads is a spider-web grid, which is not quite a new thing. It has about twelve radial arterials and three ring roads, one a fast traffic ring, and it is designed to give facilities for quick egress from Central London. The theory is to get rid of the fast long-distance traffic or through traffic and thus relieve the congested centres. Only one of the radial arteries is a new route. The others were built in the period between the wars. One ring road (the North Circular Road) is also partly completed. These have not relieved the congestion in the centre to any appreciable extent. Of course, you can by-pass a very small town between two big cities, where there is a lot of through traffic ; but I think it is beginning to be recognised now that in London the amount of through traffic is practically negligible. It is significant that none of these new roads figure on the density chart for the last traffic census ; none of them carried sufficient traffic for that. If you come into London at one end, on the old roads, you will find a very small trickle of traffic to start with, gradually increasing until you reach the centre.

The arterial roads do not cater for London traffic as such. They do not encourage pedestrians or shopping centres ; they may carry a few country buses, but still less of the red London buses use them. Consequently, the old London roads will still become more and more congested, and nothing has yet been done to any extent to ease that congestion. It is surely time that something more was done for the old London roads. In the various plans the causes of congestion are put down as narrow streets, and so on. It is not admitted that the main cause is the cross traffic at the junctions ; this is scarcely mentioned. All these schemes so far work on the theory that the through traffic is causing the congestion ; but it is nothing of the kind. It is true that it is proposed to re-organise the principal intersections by the construction of roundabouts. This looks like a tardy admission that the cause of congestion is cross traffic. If so, why use roundabouts ? They do not get rid of the cross traffic. They have failed in Paris and New York ; the principal roundabouts in London have failed to function as free gyratory systems, and the crossings have had to be controlled by signal lights, so that the traffic collects and is released in blocks. I showed, eleven years ago, that the roundabout did not get rid of any of the cross traffic, that the cross traffic was the cause of the congestion, and that it could only be dealt with by means of a fly-over.

In the County of London Plan the over-passes shown are great sprawling contraptions 500 yards long ; it is doubtful whether there will be room for all of them on the fast ring road, which shows a roundabout every half mile or so. They take up more room and are more costly, more unsightly and less efficient than a properly designed fly-over, which can be provided in 200–300 yards, and will eliminate at least four-fifths of the cross traffic which is the root cause of congestion.

The design of the fly-over crossing is a complex three-dimensional problem. It is of little use to go abroad for examples of fly-overs, because in foreign countries they are provided mostly in the open country where they take up 500–1,000 yards for a four-way crossing (two arterial roads crossing), whereas I showed many years ago a design for an urban district taking only 200 yards. Even for a six-way (three arterial roads crossing) it can be done in 350 yards or so.

I have models here of two fly-overs I have designed for the Elephant and Castle and Hyde Park Corner. The former scheme, prepared ten years ago, was examined by Sir Charles Bressey when he was making his survey. He approved it in every part, but did not put it in his report which was not concerned with details. As will be seen from the model, my scheme provides a complete solution of the traffic problem at Hyde Park Corner, with one bridge, without excessive grading. Cross traffic increases as the square of the density ; i.e., you have four times as much for two line and nine times as much for three line density. I have worked out the figures for three-line density and three-way distribution, for roundabouts and fly-overs at six-way and four-way junctions. The figures are astonishing. The six-way roundabout has four times as much cross traffic as the four-way. As compared with a bridge scheme or fly-over, at the four-way crossing the cross traffic at the roundabout is five times as much as in the bridge scheme, but at the six-way crossing (three arterials) the roundabout has fourteen times as much cross traffic as the bridge scheme.

It seems to me that if, as so many have suggested, a really big scheme cannot be started until it is thoroughly thrashed out, we could get back some of the lost value of these roads if some of the main junctions were re-organised. At many of the junctions we could do something at once which would fit in with any subsequent plan, and would at least make a start in dealing with the problem of congestion.

Mr. J. E. Allen

SIR ALKER TRIPP said that, of the vast majority of accidents in London, which are due to human errors, one-third are due to motor drivers, one-third to pedestrians and one-fifth to pedal cyclists. Those figures are not accepted by the Pedestrians' Association, who maintain that about 90 per cent. of the road casualties are caused by the speed of motor vehicles.

The various plans for London contemplate an expenditure of many millions of pounds sterling ; but there is no suggestion in any of the plans, so far as I know, as to how that money is to be raised. It must come either from the taxpayer or the ratepayer or from the owners of motor vehicles. London has no right to call upon the taxpayers of England for the advantage of the ratepayers of London ; I do not know whether the London ratepayers are prepared to pay. A large part of the cost should be thrown on the owners of motor vehicles. Lord Stamp, who was President of the British Association some years ago, said it was doubtful whether motorists paid any taxation at all, bearing in mind the damage they did to the roads.

There are three grounds on which you can tax motorists. First, there is the use of the public highway ; its use by motor vehicles is different in kind and degree from the use of highways by horse traffic. Then there is parking ; you want parking facilities all over London, I suppose at the public expense. Then there is the use of the permanent way. The road to the motorist corresponds to the permanent way of the railway companies. The railway companies have paid for their own permanent way, they maintain it and light it and police it. I do not see why our road system should not be regarded as a revenue-earning property, just as are the tracks of the railway companies.

Road traffic makes lower charges than the railway companies. That lower cost is only possible because the road vehicles are allowed to throw a very large part of their running costs on to the ratepayers.

London was built where it is because the Thames is where nature put it. In the days of the Stuarts, the Tudors, and possibly the Plantagenets, the Thames was the main artery of London's traffic. Why is it not the main artery of London's traffic now ? My proposal is that the Thames be converted into a freshwater lake by putting a high-tide barrage somewhere about Woolwich.

Sir William Halcrow

WE have had a very useful discussion this morning. It has been recorded and will be published, together with the papers read yesterday, by the British Association. I think the conference should afford valuable assistance to those upon whose shoulders will rest the responsibility for planning and on behalf of the Association I would thank all who have presented such interesting papers and who have contributed to the discussion.

NOTES

(1) A number of plans affecting the reconstruction of London may be said to constitute 'The London Plan.' They may be summarised as follows :

1937 *Highway Development Survey.* By Sir Charles Bressey and Sir Edward Lutyens.
1942 *London Replanned.* Report by Royal Academy Planning Committee.
1943 *The L.C.C. Plan.* By Sir Patrick Abercrombie and J. H. Forshaw.
1943 *Greater London—Towards a Master Plan.* Report by the London Reconstruction Committee of the Royal Institute of British Architects.
1944 *The Greater London Plan.* By Sir Patrick Abercrombie.
1944 *Road, Rail and River in London.* Report by Royal Academy Planning Committee.
1946 *Railway (London Plan) Committee's Report* to the Minister of War Transport.
1946 *The City of London Plan.* By Messrs. Holden and Holford.

(2) The following are notes on those who contributed to the first two sessions of the Conference.

Sir Richard Gregory, Bt., F.R.S., President of the British Association.
Rt. Hon. Lord Latham, Leader of the London County Council.
Sir William Halcrow, President of Section G (Engineering) of the British Association. President of the Institution of Civil Engineers.
Sir Alker Tripp, C.B.E., Assistant Commissioner of Metropolitan Police.
Prof. W. G. Holford, M.A., A.R.I.B.A., responsible, jointly with Dr. Holden, for *The New Plan for the City of London*, 1946.
W. H. Ansell, M.C., Past-President of the R.I.B.A.
A. J. Lyddon, C.B.E., M.I.C.E., formerly Deputy Chief Engineer, Roads Dept., Ministry of Transport, now Director of Federation of Coated Macadam Industries.
V. A. M. Robertson, M.C., C.B.E., formerly Chief Engineer, London Passenger Transport Board, now Chief Civil Engineer, Southern Railway.
E. Colston Shepherd, B.A., B.Litt., formerly Editor of the *Aeroplane*, now Secretary-General, Air League of the British Empire.
H. F. Cronin, M.C., B.Sc., M.I.C.E., Chief Engineer of the Metropolitan Water Board.
J. C. Martin, O.B.E., M.I.C.E., Assistant Engineer (Tunnelling) London Passenger Transport Board.

THE NUMBERS AND DISTRIBUTION OF MANKIND

By C. B. Fawcett

In 1938 the American and British Associations for the Advancement of Science established an exchange lecture known as the British American Association Lecture to be delivered in alternate years in America and Britain. The American Association invited Professor C. B. Fawcett to deliver the lecture at their Annual Meeting in Boston, in December 1946, and the text is printed here by arrangement with the Executive Officers of the American Association.

The problems presented by the distribution of the human population over the surface of the land, and its relations to the natural resources of the earth, form the principal subject-matter of Human Geography.[1] Our knowledge of these matters is still very inadequate. There are wide margins of error in the available statistical material,[2] and still wider gaps in our knowledge of the earth's resources. Yet it seems worth while to attempt to set out some of the facts bearing on these problems as fully as possible.

In this address I shall attempt to consider briefly only three of the groups of factors in these problems :

(1) that of the actual magnitude of the present human population, and the main features of its distribution over the land surface.
(2) the relation between the distribution of the population and that of the fertile lands from which the food of mankind is obtained.
(3) on the basis of the first two factors I have ventured to estimate the population-capacity of the world on some existing standards of production and consumption.

Numbers

The first question is ' How many people are there in the world to-day? ' It is not possible to answer this question exactly. In most of the lands of Western Civilisation, and in many other lands under their control, fairly reliable censuses[3] have been taken. So we can state the numbers of the inhabitants of Europe and North America, of the countries of the south temperate zone, and of Japan and India, with some approach to accuracy. But for the large population of China, and for the inter-tropical lands of the Americas and Africa we have only estimates of very varied value ; some of these estimates are based on partial censuses, some are hardly more than guess-work.

Thus there is necessarily a wide margin of error in all estimates of the world's population, which should be remembered in studying the following figures.

Table I.—Estimates of the World's Population[4]

Authority	Date	Population in millions
E. Levasseur	1908	1,626
Sir G. H. Knibbs	1914	1,649
Times' Atlas	1921	1,646
International Institute of Agriculture	1921	1,820
Statistical Yearbook of the League of Nations	1931	2,025
Statistical Yearbook of the League of Nations	1940	2,145

These estimates do not form a concordant series. In Europe and North America the chief areas of doubt were Russia and Mexico respectively. In Asia the whole difference may be explained by various estimates of the population of China ; but there is equal uncertainty as to the numbers of the peoples of south-west Asia. There were wide differences in the estimates of the population of

[1] E.g. Part I of F. Ratzel's *Anthropogéographie* is given to this topic ; so also is Part I of P. Vidal de la Blache's *Principes de Géographie humaine*.

[2] Because of these difficulties all the figures used in these calculations are round numbers ; none of the resulting estimates should be regarded as more than first approximations. *Cf.* the General Note on p. 13 of the *Statistical Yearbook of the League of Nations*, 1940.

[3] Where most of the people can read and write a census can be fuller, and more accurate, than among an illiterate people. Also great mobility among a people, as in the United States, makes for less accuracy in the census. No census is quite accurate ; but I have no data for a numerical estimate of census errors.

[4] Levasseur, ' La Répartition de la Race Humaine ' in the *Bulletin de l'Institut International de Statistique*, 1909, pp. 48–63. Knibbs, *The Mathematical Theory of Population*—Appendix A to the First Census of the Commonwealth of Australia, 1917, p. 31. *The Times' Atlas*, London, 1922, see Plates 5 and 7. *International Yearbook of Agricultural Statistics*, 1909–1921, published in 1922 at Rome. *Statistical Yearbooks of the League of Nations*, 1932–33, and 1939–40. See also A. M. (now Sir Alexander) Carr-Saunders' *World Population*, Oxford 1936.

Africa, which illustrate the difficulty in respect to the numbers of barbarian peoples. Estimates of the population of the Belgian Congo have ranged from 30 millions down to 8 millions.[1]

The next table (II) states some of the recent estimates of the population of China, to illustrate the differences in regard to the principal area of doubt in estimating the total numbers of mankind.

TABLE II.—POPULATION OF CHINA AND ITS DEPENDENCIES [2]

Authority	Date	Population in millions
Mingchingpeng Census	1910	324
Government Gazette, Pekin	1911	315
China Continuation Committee	1918	441
Chinese Post Office	1920	428
Times' Atlas	1921	321
Chinese Maritime Customs	1922	443
Chinese Post Office	1922	433
Statistical Yearbook of the League of Nations	1931	450?
Ministry of the Interior (Nanking)	1931	475
Statesman's Yearbook	1931	486
Statistical Yearbook of the League of Nations	1940	450?
Statesman's Yearbook	1946	458

The census of 1910, which was the basis of the estimate of 1911 and perhaps also for that of the *Times' Atlas*, was a census of households. The multiplying factor (the assumed average number of persons per household) was not the same in all the provinces, and is open to doubt.

From the figures here given it appears that the population of the world has increased by about 25 per cent. since 1911, and that of China by nearly 50 per cent. But since 1911 China has suffered from revolution, followed by years of internal disorder, from civil war, and from foreign invasion on a very large scale. There have also been floods and famine and pestilence. The extent of these disasters and their persistence over more than thirty years make it unlikely that there has been any considerable increase in the population of China over this period. In India the influenza epidemics of 1918–20 almost cancelled the natural increase of population for the intercensal decade 1911–21, in which the net increase was only 0·9 per cent. Europe has undergone two great wars, and the resulting famines and pestilence, since 1914; while Russia has also suffered revolution, civil war and further famine. These facts taken together make it improbable that there has been any large increase in the total world population since 1914, in spite of the growth in the New World.

In view of these doubts and of the variations in many of the estimates which have been quoted, it is impossible to give an exact figure for the world's population. The total is probably somewhat less than 2,000 millions (2×10^9).

GROWTH

The experience of the civilised lands during the last two centuries has accustomed us to the conception of a continually increasing population. From 1801 to 1921 the population of England and Wales multiplied more than fourfold [3] in spite of a considerable emigration. Since 1800 the total population of Europe has increased from 175 millions [4] to 500 millions, in spite of the emigration of not less than 40 million [5] people. Under specially favourable conditions some smaller populations have increased even more rapidly. The French Canadians now number about 4 millions. Practically all of them are descended from the 5,800 immigrants who reached Canada before A.D. 1680 when immigration from France ceased.[6] This gives more than six-hundredfold increase in 260 years.

During the first decade of this century the mean rate of increase in the countries which had regular censuses was 1·159 per cent. per annum.[7] At this rate the numbers would be doubled in a little more than sixty years. If this had been the average rate of increase in the past, the whole of the present population of the world would be descended from one couple living near the end of the first century B.C. (The date of the expulsion from the Garden of Eden?) If it could be maintained

[1] E. M. East, *Mankind at the Crossroads*, London, 1924, p. 100. Levasseur, op. cit., gives 20 millions. *Philip's Handy Reference Atlas*, London, gives 16 millions in 1900 and 20 millions in 1913. *Annuaire de la Belgique et de la Congo Belge*, 1914, gives 15 millions, and in 1945, 10 millions.

[2] The first and fourth figures are from the *China Yearbook*, 1922; the second, sixth, seventh, ninth, tenth and twelfth from the *Statesman's Yearbook*, 1924, 1932 and 1946; the third is from P. M. Roxby's 'The Distribution of Population in China,' in the *Geographical Review*, Jan. 1925; the fifth is from Plate 7 of the *Atlas*.

[3] From 9 millions to 38 millions; figures from the Census Reports.

[4] Estimate of Levasseur, op. cit., and see J. Haliczer's 'The Population of Europe, 1720, 1820, 1930,' in *Geography*, 1934.

[5] To the United States alone more than 33 millions. F. J. Warne in *Annals of the American Academy of Political and Social Science*, Jan. 1921.

[6] G. E. Marquis, on p. 7 of the volume *Social and Economic Conditions in Canada*, published by the American Academy of Political and Social Science, May, 1923.

[7] Knibbs, op. cit., p. 31. See also article by F. Shirras, in the *Economic Journal*, March, 1933.

in the future, then in another thousand years the earth would have about 25 millions of millions (25×10^{12}) of human inhabitants, i.e. more than one to every square yard of land. Such calculations make it very obvious that the recent average rates of increase among the civilised peoples are far greater that those which existed in the past; and also that such rates of increase cannot be maintained for any considerable time.

Evidently we have been living in a period of exceptionally rapid increase of population. But it is clear that we are approaching the end of that period; for the birth-rates are now falling, more rapidly than the death-rates, in a large part of the civilised world. While in the past the direct check to a too rapid increase in numbers was usually the existence of a high death-rate, in particular of high rates of infant mortality, it is now attributable chiefly to a fall in the birth-rate. Mankind is now able to choose which of these two checks shall be applied; but one of them must be. If the naturally rapid increase in numbers is not controlled by human acts, the appeal will be to the ancient trinity of 'War, Pestilence and Famine.' For the surface of the earth is incapable of expansion; and its resources, though great and capable of much fuller utilisation, are limited.

Recent Expansion

We may note very briefly the conditions which made possible the great and sudden expansion in the numbers of the European peoples in the nineteenth century. Evidently these conditions affected the English-speaking peoples to a greater extent than any others; for their numbers have increased ninefold since the beginning of last century. They now form more than a fourth of all the peoples of European origin, whereas in 1800 they were less than one-eighth.

It is clear that this particular expansion is chiefly due to the peopling of North America; for that continent now contains two-thirds of the English-speaking peoples, whereas it contained only one-fifth of them in 1800.[1] The growth began with the Industrial Revolution, when the applications of mechanical power increased the production of manufactured goods and so led to an increase in the populations of the industrial areas. The increased demand for food was at first met by a more intense cultivation of the homeland; but the insufficiency of this source of food was shown in the 'Hungry Forties' of last century. The pressure of a hungry people removed fiscal barriers which had hindered the free import of food; while the improvements in transport made the virgin lands west of the Appalachians accessible; and the population of Great Britain multiplied on a food-supply obtained from oversea. The demand stimulated the colonisation of North America and the even greater increase of its population. But there is little likelihood of the discovery of another 'New World' to allow another such expansion of numbers until Man conquers the equatorial jungles.

[1] Populations of the English-speaking peoples in millions. (Whites only).

1801	British Isles	15·9	1931	British Isles	49	
	Canada	0·1	1941	Australia and N.Z.	9	59
1800	U.S.A.	4·3		South Africa	1	
				Canada and Newfoundland	8	127
			1940	U.S.A.	119	
	Totals	20·3			186	

Distribution

The final limiting factor to the growth of population is that of the food-supply; and since Man must obtain practically the whole of his food from the land,[2] the next important questions in this study are 'What is the extent of the available land?' and 'How much of this land is capable of being used for the support of mankind by the production of materials, for food, shelter and tools, with which to satisfy human wants?'

The area of the lands outside the Polar Regions is known to a fair degree of accuracy. Omitting the permanently icebound lands the total area of the remainder, the available land, is about 50 million square miles.[3] Thus the average density of population is nearly 40 persons per square mile, a figure which may be of some interest as a basis for comparisons; though in fact the density varies very widely, and the most characteristic feature of the distribution of population is its extreme unevenness.

Of the of total 2,000 million people the greater number live in three comparatively small regions of particularly favourable environment. (See Fig. 1.) In the north-west of the Old World the populous region of 'Europe' is limited on the north by the parallel of 60° N. latitude and the upper valley of the river Volga, on the east by the Ural mountains and the Caspian and Persian deserts, and on the south by the

[2] It is not possible to determine with any precision what amount or proportion of human food is obtained from the sea. This does not affect the value of our estimates of population-capacity; since these supplies are included in the resources of the existing populations on which those estimates are based.

[3] C. B. Fawcett, 'The Extent of the Cultivable Land,' in *Geographical Journal*, Dec. 1930.

Sahara-Arabian desert.[1] This region contains more than 500 million inhabitants on less than three million square miles of land. In the 'Far East' the similarly populous region which includes most of China and Manchuria, the Japanese Empire south of 40° N. latitude, and Tonkin, is occupied by nearly as many people on an area of barely 1,700,000 square miles. And in India and Ceylon, between the Thar desert and the eastern edge of Bengal, there are 400 million people on about a million square miles of land. Thus in these three major populous regions of the Old World there are crowded together nearly two-thirds of the world's population on one-eighth of the available land.

have more than forty inhabitants per square mile. In other regions there are a few dense clusters on small areas round large cities, especially in South America and Australia. But outside the four great populous regions

TABLE III.—THE FOUR MAJOR HUMAN REGIONS

Continuous Habitable Region	Area in millions of sq. mls.	Population		Central Latitude
		in millions	per sq.ml.	
Europe	2·8	520	186	50° N.
Eastern North America	1·9	130	52	40° N.
Far East	1·7	500?	292	35° N.
India	1·0	400	400	25° N.

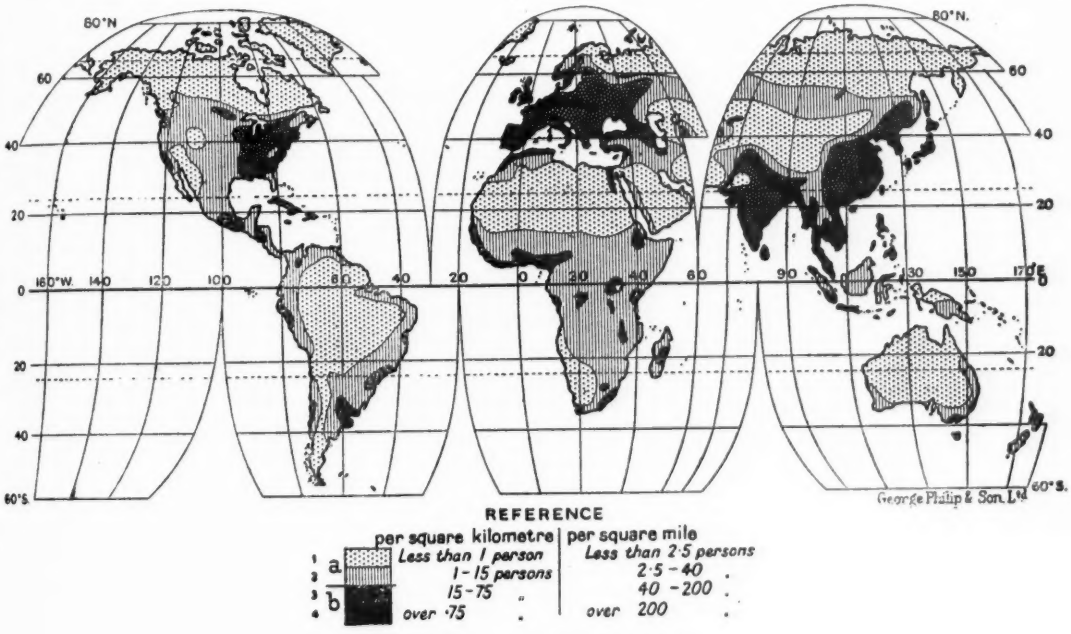


FIG. 1—World: Density of Population.
Note that the mean density for all the land is about 15 persons per km² (40 persons per sq. mile); so that *a* — marks densities below the average.
b — marks densities above the average.

There is a fourth region of the same type in eastern North America, which is comparable in extent. But, since it has been accessible to civilised man for only a few generations, it is not yet fully occupied; and it carries only the moderate population of about 130 millions on a little less than two million square miles of land.

Nowhere else on the earth is there any similarly large mass of dense population; though the island of Java is as densely peopled as England, and parts of West Africa which have been noted the remaining six-sevenths of the available land is very thinly peopled.

Next we may briefly consider the reasons for this, at first sight peculiar, distribution. Rather more than three-fourths of mankind dwell in the 'Old World,' by which is meant that part of the earth which has been accessible to civilised men during all the historic period, in contrast to the 'New World' which has been similarly accessible only since the Age of Discovery at the end of the fifteenth century. The Old World, as thus defined, includes most of Asia, Europe, and Africa north of the Sahara, and nearly half of the available land.

Over this vast area the population is in

[1] See also Sir H. J. Mackinder, *Democratic Ideals and Reality*, London, 1919; and C. B. Fawcett, (i) 'Centres of World Power,' in the *Sociological Review*, April, 1926, (ii) 'The Changing Distribution of Population,' *Scottish Geographical Magazine*, Nov. 1937.

fact distributed in general accordance with the food-producing capacity of the various regions. The fertile areas are densely peopled—the barren lands are comparatively empty. All the oases of the deserts are, or have been, occupied ; and many of them are crowded. By a process of trial-and-error, which has already extended over some thousands of years, men have succeeded in establishing themselves in all the parts of these lands which can be made to provide subsistence. Though the knowledge and equipment gained by Western Civilisation in the last two centuries has made it possible to utilise lands which could not be occupied by civilised man before, as for instance in Siberia ; yet the general adjustment of population to natural resources in the Old World is the best available guide to the possibilities of maintaining any comparable masses of population in the newer lands of the earth.

Elsewhere [1] I have estimated the extent of the cultivable land of the world at 30 per cent. of the total land area, i.e. about 16 million square miles. Hence I assume in the rest of this address that that area, less than a third of the available land, is cultivable. Another 30 per cent. may be classed as ' productive ' but not cultivable ; and the rest (40 per cent.) is occupied by the deserts (cold and dry). (See Fig. 2.)

The productive but uncultivable third of the land is mainly divided between areas of forest and poor grazing land, such as the mountain and hill pasture of north-west Europe and the semi-arid ' range ' or ' bush ' of North America and Australia. The wetter areas of this land are often suitable for forest ; so are some considerable areas on the margins of the tundra, where the hardier conifers can grow although the lack of sufficient summer heat prohibits agriculture. The semi-arid regions, and the summer pastures of the tundra and the high mountains, are likely to remain grazing lands.

The wet forested lands of the Hot Belt, which are included in the cultivable land of our estimate, offer the chief possibilities of any considerable extension of the cultivated land. Everyone who has studied the matter must have been impressed by the contrast between the island of Java, which supports a population as dense as that of England, and the uncultivated wastes of forest and savanna which occupy the greater part of the Hot Lands. A few other small tracts of these lands are relatively well-cultivated and populous, as in parts of the African Lakes region, the Benue valley of Nigeria, and parts of Upper Guinea. In South America there seem to be no correspondingly populous patches ; though the vast Amazon Lowland is a region very favourable to vegetable life. Here the chief obstacles to cultivation appear to be (*a*) the combination of heat and humidity, which forms a most enervating climate, (*b*) the very marshy character of much of the region, which is deltaic in character and can only be reclaimed for cultivation by a great expenditure of labour, (*c*) the density of the jungle and the rapidity of plant growth, (*d*) the scarcity of labour, and (*e*) the lack of any immediate incentive strong enough to induce any civilised people to attempt the task of colonising in this region.

It is significant that the chief crops which are now under cultivation in the Hot Lands are broadly divisible into two distinct categories. The one includes the trees or shrubs of the plantations whose produce forms a money-crop for export to the populous lands of the mid-latitude zones, such as tea, coffee, rubber, bananas, oil-palms. These are usually grown on well-drained slopes in the hilly areas. The other consists of local food plants, such as the rice and associated annuals of the wet irrigated flat lands of the deltas and valley bottoms of the East Indies.

Up to the present, the efforts of European and North American planters in the Hot Lands have been directed mainly to the first group of products, and therefore to areas of considerable relief. Their plantations and habitations avoid the wet and marshy lowlands. Only incidentally, through the growth of a local food-supply for their work-people, have they developed cultivation of the second type, as in the rice-fields of the Guiana coast. Yet the experience of the planters has sufficed to show the nature of many of the obstacles to be overcome in bringing the fertile lands of the Hot Belt under cultivation. It justifies the prediction that these lands will only be reclaimed for Man under great economic pressure, and at the cost of enormous amounts of labour. The peoples of the temperate regions are not likely to migrate to the Hot Lands in any considerable numbers so long as they can find room in the more attractive lands of their own climatic zones. Therefore Man's effective conquest of the equatorial regions will be postponed until necessity drives him to the task.

Population-Capacity

In discussing the numbers of the people who can be supported on the world's resources, which we may call its population-capacity, we are in fact studying the possibilities of the food-supply. There are three

[1] ' The Extent of Cultivable Land ' in *Geographical Journal*, Dec. 1930.

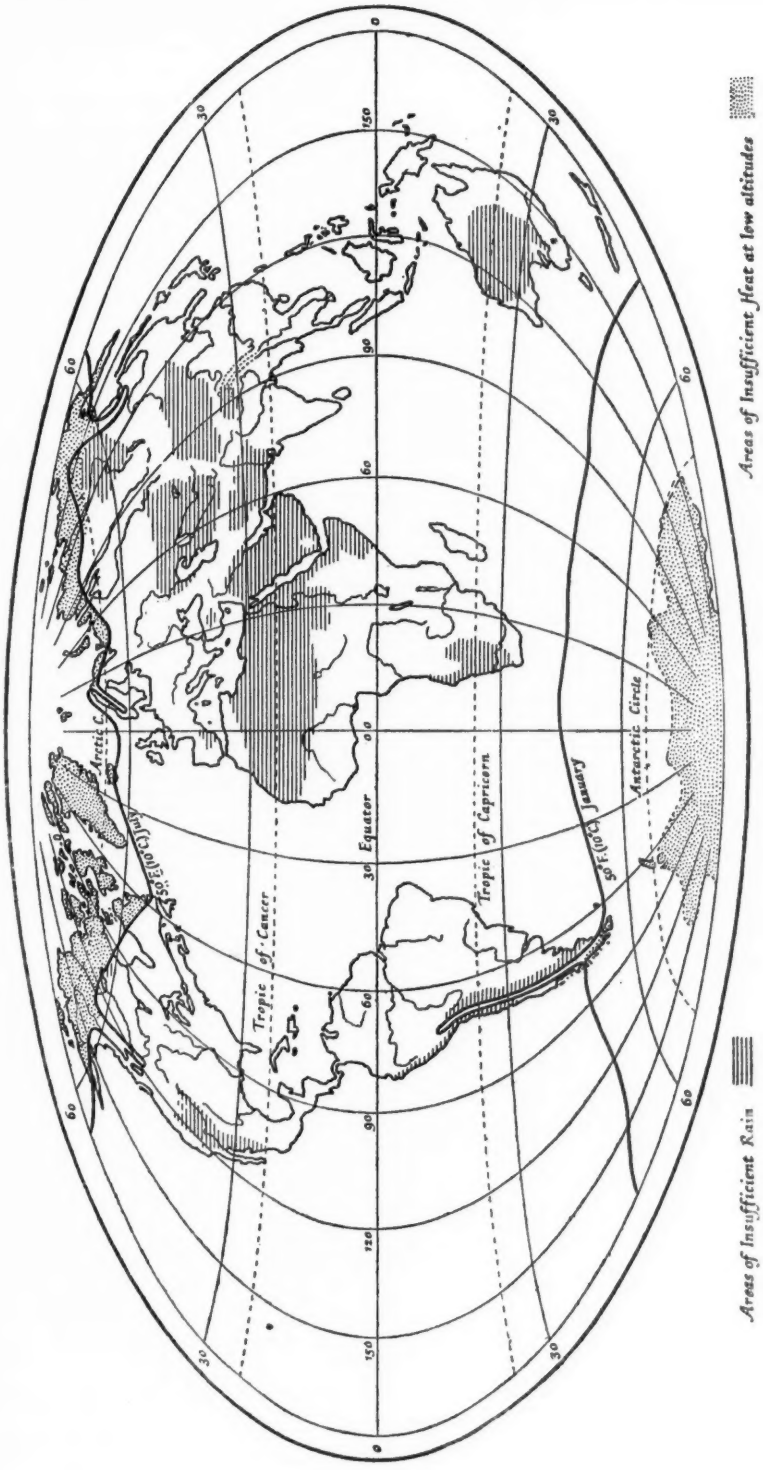


FIG. 2
(Map reproduced by permission of the Royal Geographical Society)

sets of conditions on which we may base estimates.

(1) We may assume that the principal foods and the methods of producing them will remain much as they are to-day; and that the increase of supplies will only be that due to raising the standards of cultivation in backward areas, using improved strains of food plants and animals, and making full use of all the cultivable land.

(2) We may make the additional assumption that Man will, in the near future, overcome the difficulties of cultivation in the wet lands of the Hot Belt and add them to his area of cultivation.

(3) We may guess at more or less speculative advances in the developments of science applied to food production, which may enable Man to increase the food-supply very largely.

Also we should bear in mind that the number of people who can be maintained at any given level of production varies inversely with their standards of living. It seems probable that the civilised peoples will prefer to check the increase in their numbers rather than accept a lower standard of living.

On the first assumption, that the present methods of food production will be extended but not greatly modified, we may calculate the world's population-capacity on the basis of France and British India. These lands are chosen because

(*a*) both of them ordinarily produce sufficient of their staple foods for their own needs, on their present standards.

(*b*) both are 'old' lands, and are fully peopled under present conditions.

(*c*) fairly reliable statistics are available for both.

(*d*) they offer a contrast in type of climate and have different staple food plants.

France is a fair instance of conditions in one of the long-civilised countries of Europe which is still, under normal conditions, self-supporting in respect of her necessary foodstuffs; and the standards of living of the French are probably a little above the average of those of the rest of Europe. In France no less than 90 per cent. of the land is classed as 'productive' and half of it as cultivated.[1] The density of the population is a little over 400 persons per square mile of cultivated land. At this rate the cultivable land of the world would be able to provide food for 6,500 million people (65×10^8), more than three times the present population.

In British India the mean density of the population is more than 600 per square mile of cultivated land; so that on the present standards of India the world might maintain nearly 10,000 million (10^{10}) inhabitants, five times the present population.

But it should be remembered that in bad years neither France nor India is able to produce all the food needed by her people. After a bad harvest France must import wheat; and a failure of the monsoon rains may bring famine to large areas of India. If the whole world were peopled up to its full normal capacity on these standards of production and consumption of food, it would in fact be over-peopled; and the surplus population would be periodically removed by famine.

Our second assumption is that the pressure due to an increasing population and a falling standard of living may compel mankind to utilise all the cultivable lands of the Hot Belt at least as fully as those of some small areas in it are now used. At this rate that portion of the cultivable land which lies in the Hot Belt, nearly a quarter of it or four million square miles, might be capable of producing food[2] for a population as dense as that of Java. That island contains 42 million people on 50,000 square miles of land, of which a little less than 60 per cent. is cultivable; so that the density per cultivable square mile is about 1,200. If we take France as our basis for the mid-latitude lands and Java for the Hot Lands the possible population becomes 9,600 millions (96×10^8), which is nearly the same total as our second figure based on Indian standards.

In relation to the third assumption we should note the existence of such views as those put forward by the late Prince P. Kropotkin,[3] who could see no limits to the productivity of the land and claimed that the food production of England, and other countries, could be easily doubled by the application of intensive methods of cultivation. Such an increase would, however, more than double the labour cost of the products and so tend to lower the standards of living. It is true that agricultural productivity can be increased by such expenditure of labour and capital, and still more by the application of the results of scientific investigation into its problems. Many optimistic forecasts have been made; but I know of no data sufficient to justify even an intelligent guess at the limits of such productivity.

It is clear from the estimates here given

[1] *International Yearbook of Agricultural Statistics.*

[2] It is well to note that the possibilities of transporting perishable foods are likely to improve still more. Hence such an increased amount of food might be used to feed the people of the temperate lands so long as their economic and military power enabled them to take it.

[3] P. Kropotkin, *Fields, Factories and Workshops*, London, 1898, and several later editions.

that the world, as a whole, is capable of supporting a population much more numerous than that which it carries to-day. The immediate problems of over-population are limited to some few areas ; and the present-day ' pressure of population ' [1] is not against the limited resources of the earth but against the various barriers, natural and artificial, which hinder access to those resources. Yet the fact that the size and natural resources of the earth are fixed and limited ensures that its human population can not increase indefinitely. With our present powers of production the world may be able to support three times its present population in reasonable comfort. But if the present rates of increase are maintained that number will be reached in less than a century from now.

[1] C. B. Fawcett, ' Pressure of Population,' in the *New Commonwealth Quarterly*, London, Jan. 1943.

THE BRITISH ASSOCIATION

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